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THE DISTRIBUTION AND ABUNDANCE OF CHINOOK SALMON (Oncorhynchus tschawytscha) IN THE UPPER YUKON RIVER BASIN AS DETERMINED BY A RADIO-TAGGING AND SPAGHETTI TAGGING PROGRAM: 1982 - 1983.

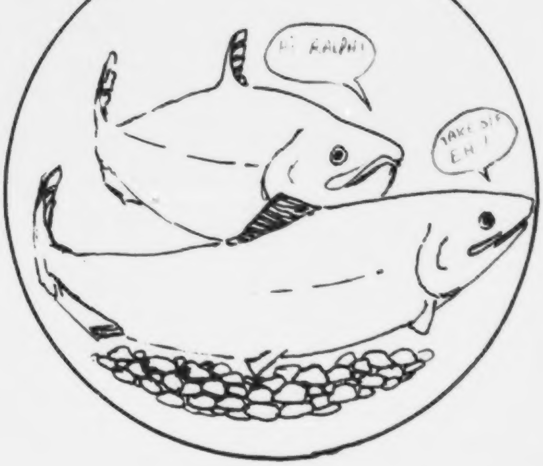
P.A. Milligan, W.O. Rublee, D.D. Cornett and R.A.C. Johnston.

YUKON RIVER BASIN STUDY

This project was completed for the Yukon River Basin Study, an intergovernmental study funded by the governments of Canada, Yukon and British Columbia.

Fisheries and Oceans
Pêches et Océans

Whitehorse, Yukon 1984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TAKE 'ER EH!

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Department of Fisheries and Oceans
Whitehorse, Yukon
1984

YUKON RIVER BASIN STUDY
TECHNICAL REPORT:
FISHERIES NO. 5a

THE DISTRIBUTION AND ABUNDANCE OF CHINOOK SALMON (Oncorhynchus tshawytscha) IN THE UPPER YUKON RIVER BASIN AS DETERMINED BY A RADIO-TAGGING AND SPAGHETTI TAGGING PROGRAM : 1982-1983

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June 1984

DEPARTMENT OF FISHERIES AND OCEANS
WHITEHORSE, YUKON

This report was funded by the Yukon River Basin Committee jointly with the Department of Fisheries and Oceans under the terms of "An Agreement Respecting Studies and Planning of Water Resources in the Yukon River Basin" between Canada, British Columbia and Yukon. The views, conclusions and recommendations are those of the authors and not necessarily those of the Yukon River Basin Committee or the Governments of Canada, British Columbia and Yukon.

SUMMARY

A two year study of the distribution and abundance of adult chinook salmon within Canadian portions of the Yukon River Basin was conducted in 1982-83. This study was initiated as part of Fisheries and Oceans' contribution to the Yukon River Basin Study.

Chinook salmon were live-captured by fishwheels positioned on the Yukon River above the Canada/U.S. border. Spaghetti tags were applied to 265 chinook in 1982 and 1,266 chinook in 1983 as part of a mark-recapture program. Radio transmitters were implanted in 130 chinook in 1983. Radio-tagged chinook were tracked into all sub-basins within the study area. The mean migration rate of radio-tagged chinook in the Yukon portion of their migration was 36 $km.day^{-1}$. Chinook migration through the Dawson area involved a large number of "mixed stocks" bound for widely separated spawning tributaries.

Population estimates of 36,598 and 47,741 chinook were determined for 1982 and 1983, respectively. The overall chinook exploitation rate for the commercial, native subsistence, and domestic fisheries in the study area was 35.1% in both 1982 and 1983. The total exploitation rate may have been underestimated because of unreported tag returns and it could approach 40-45%. The trend in the commercial fisheries is towards increased catches. This has resulted from the establishment of processing and marketing facilities.

Biological information was collected from the tagged sample, commercial fisheries, and on the spawning grounds. Chinook return to spawn at four to eight years of age, although eight year old chinook are uncommon. Five, six and seven year old chinook are the dominant age classes harvested in the commercial fishery in the Yukon Territory. This fishery is highly selective for the larger age classes, particularly six year old females.

Naturally occurring chinook stocks spawn in 61 streams within the study area. The number exceeds this total if each discrete mainstem spawning area is included. Spawning habitat includes mainstem area, both small and large tributaries, and lake outlets. The majority of the spawning areas are associated with lake-fed systems which are most prevalent in the south-central portions of the Yukon River Basin. The number of new spawning areas identified in this study was lower than anticipated. The majority of the spawning areas that support 100 or more chinook have probably been identified. A small number of undocumented spawning areas may exist in mainstem locations and in the more remote areas of some sub-basins. Many of the spawning areas that have been identified are underutilized at the present time and many existing chinook populations appear to be remnants of larger historic returns. The most obvious explanation for this is heavy fishing pressure in Alaskan and Canadian fisheries and possibly foreign interception in high seas fisheries. In general, spawning and rearing habitat have not been seriously impaired in Canadian portions of the Yukon River Basin.

Chinook populations could be enhanced through preliminary techniques such as increasing escapement levels.

The major recommendation of this report is that the Department of Fisheries and Oceans initiate some form of joint management and research with the Alaska Department of Fish and Game. This is necessary because Canadian bound chinook stocks are intercepted in Alaskan fisheries on the lower Yukon River during their upstream migration. Available information suggests that Canadian spawning areas produce approximately 50 % of the Yukon chinook salmon resource.

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1.0 INTRODUCTION

In 1982, the Department of Fisheries and Oceans commenced a two year study of adult chinook salmon (Oncorhynchus tshawytscha Walbaum) in the Yukon River Basin. The study was undertaken as part of Fisheries and Oceans contribution to the Yukon River Basin Study (a joint study by Canada, Yukon, and British Columbia of the water and related resources of the Yukon River Basin).

The general objectives of the study were twofold:

1. to quantify the number of chinook salmon returning to the Canadian portion of the Yukon River (excluding the Porcupine watershed);
2. to examine the distribution, relative abundance and migratory behaviour of specific spawning stocks.

To fulfill these objectives, two types of tagging studies were implemented: spaghetti tagging and recovery programs, carried out in 1982 and 1983; and a radio-tagging program, carried out in 1983 to complement the information collected in the tagging program.

The specific objectives of the spaghetti tagging and recovery programs were as follows:

1. to determine population estimates;
2. to determine exploitation rates and harvests in commercial, domestic and native subsistence fisheries;
3. to determine spawning escapements;
4. to determine migration timing and rates;
5. to determine biological parameters such as age, size, and sex composition.

The specific objectives of the radio-tagging program were as follows:

1. to determine the distribution of chinook salmon within the Yukon River basin;
2. to determine migratory rates and timing, behaviour, and spawning locations of individual chinook salmon stocks.

This report presents the results of these investigations. The two tagging programs are described separately. The spaghetti tagging program is described in section 2.0, and the radio-tagging program, in section 3.0. Section 4.0 includes a discussion of the results of both programs and provides pertinent recommendations. Relevant background information is provided below.

Funding for the 1982 programs was provided by:

- the Yukon River Basin Study
- The Department of Fisheries and Oceans and the Unemployment Insurance Commission through an Employment Bridging Assistance Program
- Federal Summer Canada and Career Oriented Student Employment programs.

Funding for the 1983 program was provided by:

- Yukon River Basin Study
- the Federal and Yukon Territorial Governments through a Community Recovery Program
- Employment and Immigration Canada through a New Employment Expansion and Development Program
- Department of Fisheries and Oceans
- the Federal Summer Canada Student Internship Program.

1.1 Description of Watershed

The Yukon River drainage is the fifth largest in North America in terms of land area (844,800 km^2) and mean discharge (Todd 1970). Approximately

342,875 km^2 (40.6%) of the 844,800 km^2 drainage area is located in Canada. The Yukon River originates on the British Columbia side of the north coastal mountains within 30 km of the Pacific Ocean and flows northward and westward for 3,018 km draining the southern portion of Yukon Territory and crossing the international boundary to continue through Alaska to the Bering Sea.

The Yukon River drainage in Canada consists of six major sub-basins (Alaska Department of Fish and Game 1982; Oswald and Senyk 1977; Canada 1979). These sub-basins, and their drainage areas, are as follows:

Major Sub-Basin	Drainage Area (km^2)
Pelly	50,200
Stewart	51,000
Teslin	35,500
White	38,100
Yukon mainstem	87,800
Porcupine	57,922

The Porcupine River, located in the northern Yukon Territory, was not included in the terms of reference of the study, because it drains into the Yukon River downstream of the Yukon-Akaska border, and is not considered part of the Yukon River Basin in Canada. The Yukon River Basin study area therefore consists of 238,300 km^2 in Yukon Territory and 24,300 km^2 in British Columbia (Figure 1).

In terms of drainage area, important tributaries of the Yukon River include the White, Donjek, Nordenskiold, Takhini, Teslin, Nisling, Pelly, MacMillan, Stewart, and Klondike Rivers. Major headwater lakes are the Kluane, Bennett, Marsh, Tagish, Atlin, Laberge, Teslin, and Mayo Lakes.

The Yukon River basin in Canada transects sixteen distinct ecoregions described by Oswald and Senyk (1977). These ecoregions are not reviewed in detail in this report; however, it is useful to note general vegetation, temperature, and precipitation information. Vegetation consists primarily of boreal forest and alpine

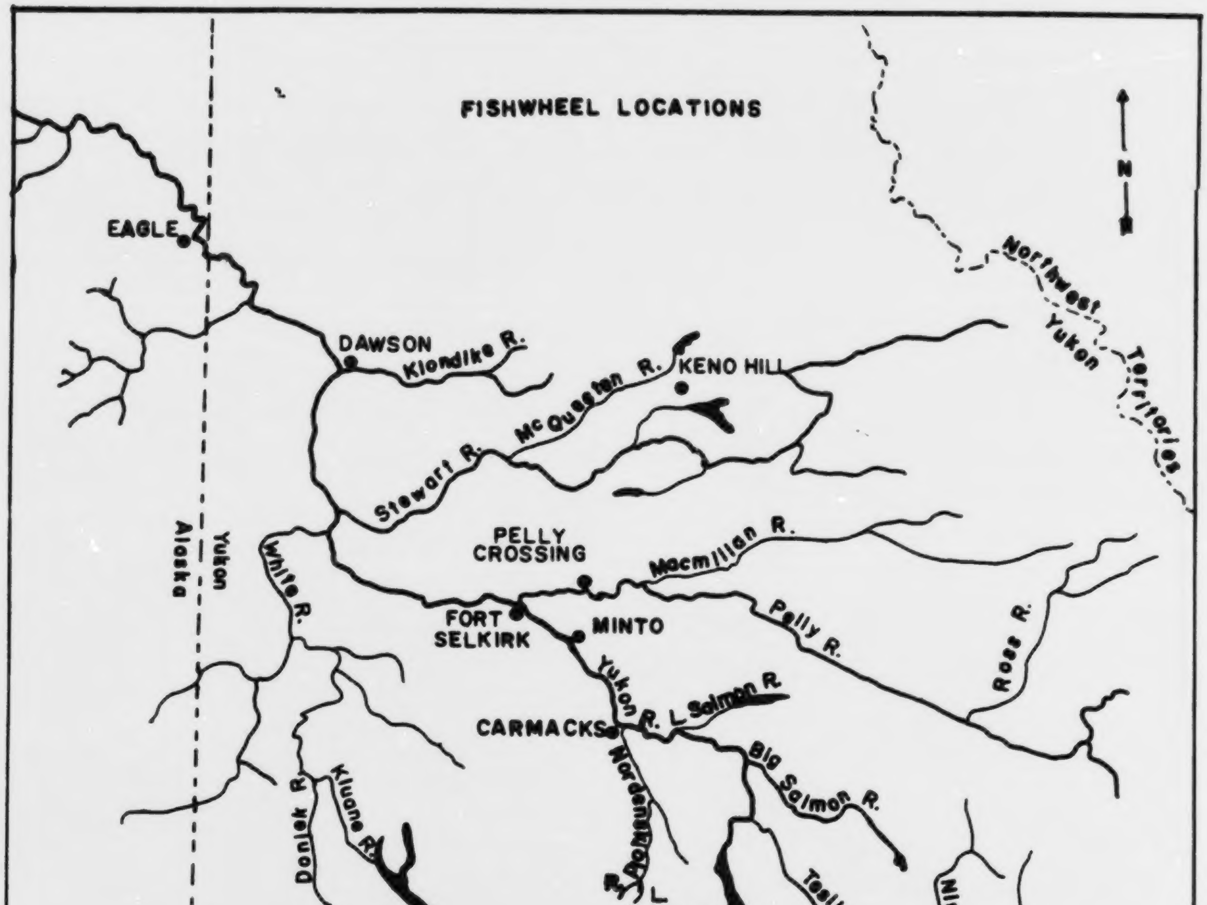
FISHWHEEL LOCATIONS
N
EAGLE
DAWSON
Klondike R.
Mc Questen R.
KENO HILL
Northwest
Yukon
Territories
Stewart R.
Yukon
Alaska
White R.
PELLY
CROSSING
Macmillan R.
FORT
SELKIRK
MINTO
Pelly R.
Ross R.
Yukon R.
L. Salmon R.
CARMACKS
Nordenskiold R.
Big Salmon R.
Donjek R.
Kluane R.
Kluane
L.
L.
Laberge
Teslin R.
Nisutlin R.
Takhini R.
WHITEHORSE
Michie
Ck.
Marsh
L.
Teslin L.
Bennett
L.
Yukon
British Columbia
Atlin
L.
Tagish
L.
Gulf of Alaska
80.0
0
80.0 km
scale
British Columbia
Alaska

Figure 1 The upper Yukon River drainage.

tundra, underlain by a zone of discontinuous permafrost. Mean annual temperatures in all regions are less than 0°C with extremes generally occurring in north-central portions of the basin. Annual precipitation is generally low, ranging from less than 375mm in the southwest Yukon to over 750mm in the east-central portions of the Basin.

1.2 Chinook Salmon Resource

The life cycle of Yukon River chinook salmon involves a freshwater rearing period of one to two years, and an ocean residence of two to six years. Adults return to spawn at four to eight years of age. The dominant age classes are six years of age followed by five year old chinook and seven year old chinook, respectively (Alaska Department of Fish and Game 1982).

Chinook salmon enter the mouth of the Yukon River from late May to early June and first appear in the Dawson area in the Yukon Territory in late June or early July. Canadian bound chinook are abundant early in the run, while stocks migrating to Alaskan portions of the Yukon River drainage are more abundant later in the run (Regnart and Geiger 1982). The chinook migration to headwater tributaries within the Canadian portion of the drainage represents the longest salmon migration in North America.

Chinook spawning is known to occur in 56 Alaskan streams (Regnart and Geiger 1982) and 55 Canadian streams (Walker 1976). Major Alaskan spawning areas include the Anvik, Andreafsky, Nulato, Hogatza, Gisasa and Salcha Rivers (Figure 2), and major Canadian spawning areas include the Big Salmon, Nisutlin, Teslin and Ross Rivers, Michie Creek, and mainstem channels of the Yukon River (Figure 1). Spawning habitat within the Canadian portions of the drainage includes both small and larger tributaries, the mainstem Yukon, and lake outlets.

The status of the Yukon River chinook resource has been determined sporadically from population estimates based on tagging programs, catch information, and escapement estimates. Chinook population estimates determined in Alaskan portions of the Yukon River drainage ranged from 161,000 to 600,000 in the 1966 - 1970 period (Table 1). Estimates of the chinook abundance determined

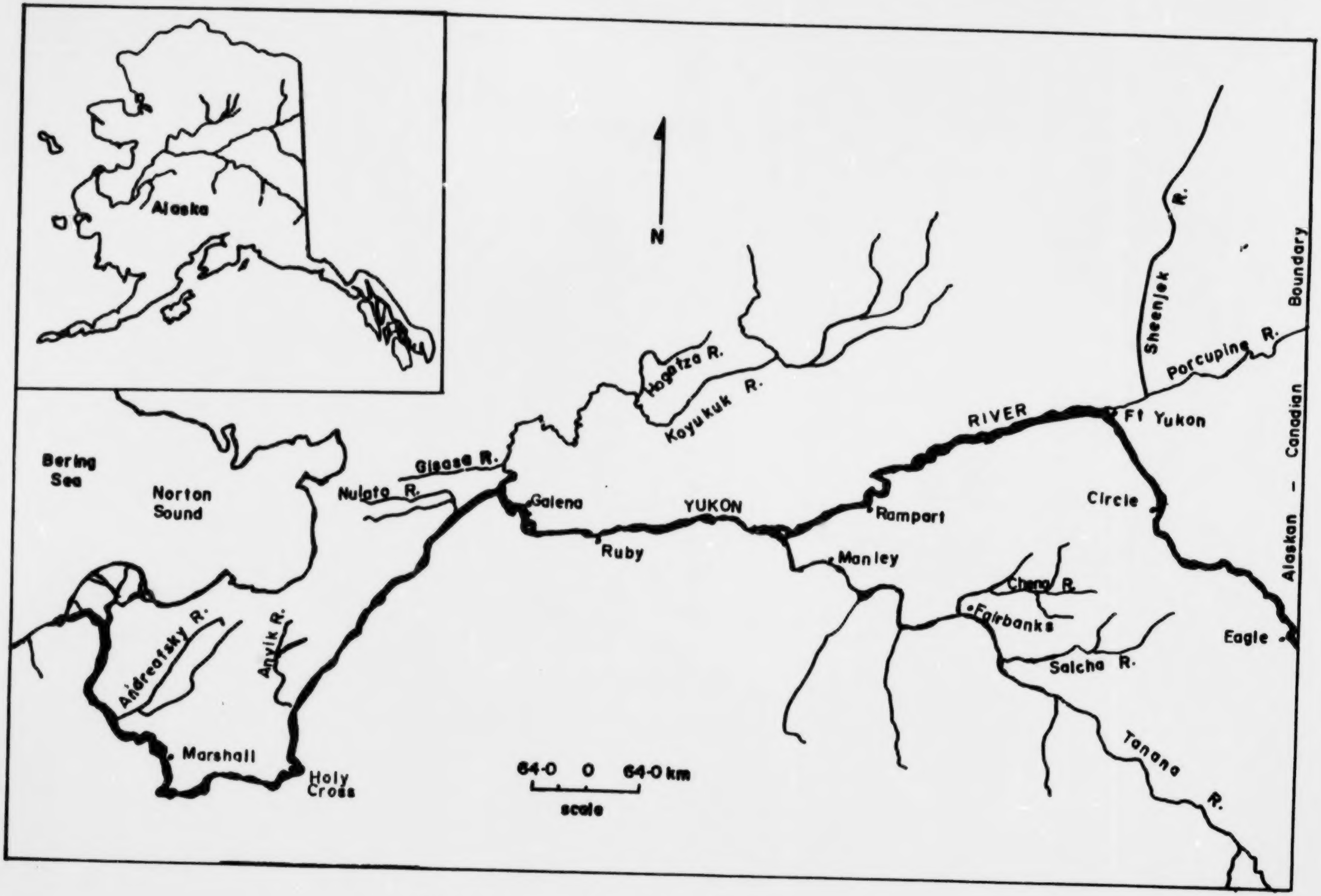
Alaska
N
Bering Sea
Norton Sound
Glasse R.
Nulato R.
Galena
Ruby
YUKON
RIVER
Hogatza R.
Koyukuk R.
Rampart
Manley
Chena R.
Fairbanks
Salcha R.
Tanana R.
Circle
Eagle
Ft Yukon
Sheenjek R.
Porcupine R.
Alaskan - Canadian Boundary
Andreafsky R.
Anvik R.
Marshall
Holy Cross
64-0 0 64-0 km
scale

Figure 2 Yukon River drainage in Alaska

TABLE 1. Previous estimates of Yukon River chinook salmon as determined from Alaskan tagging programs and catch-escapement.

Year	Location of Tagging site (km)	Population Estimate	Alaskan Catch	Canadian Catch	Combined Catch	Estimated Escapement (to nearest 100)
1961*	1,221	[a] 17,000	141,748	13,822	155,570	
1962*	1,221	[a] 22,400	105,844	14,537	120,381	
1966	0	[b]310,000-342,000	104,887	4,642	109,529	200,500-232,500
1967	0	[b]397,000 600,000	146,154	5,400	151,554	245,500-448,500
1968	296	[b]190,000	118,632	5,112	123,744	66,300
1969	296	[b]161,000	104,223	2,640	106,863	54,100
1970	296	[b]227,000	94,143	4,711	98,854	128,146

* Population estimate of chinook run upstream of Rampart

a Tag recovery with only recoveries at agency fishing sites

b Tag recovery and commercial - subsistence harvests

Reference. 1. Regnart, R., and M. Geiger, 1982. Status of Salmon Stocks, Fisheries and Management Programs in the Yukon River, A.D.F.&G., Arctic-Yukon-Kuskokwim Region, 53 pp.

2. Alaska Department of Fish and Game, 1982. Annual Management Report-Yukon Area, 148 pp.

with tag-recovery programs for Canadian portions of the drainage were 29,100 in 1973 and 36,700 in 1974 (Table 2). Above average escapements observed in most Alaskan and Canadian streams surveyed between 1978 and 1981 followed a decline that occurred between 1972 and 1976 (Regnart and Geiger 1982).

Catch, escapement and biological information pertaining to Alaskan portions of the Yukon River is annually compiled in a management report published by the Alaska Department of Fish and Game - Yukon Area, which also conducts aerial surveys and collects scale samples in selected index areas within Canadian sections of the basin in conjunction with DFO. Scale pattern analysis, which has recently been used to separate major component stocks, was used to separate chinook production into three broad geographical areas consisting of the lower, middle, and upper Yukon. The latter area consists exclusively of Canadian portions of the Yukon River Basin. The scale pattern analysis indicated that Canadian chinook production accounted for 43.4% of the 1980, and 29.3% of the 1981 Alaskan commercial chinook catches (McBride and Marshall 1983).

Information on the chinook resource within Canadian sections of the Yukon River Basin has been primarily determined from programs conducted by the Department of Fisheries and Oceans. Estimates of chinook abundance were determined from tag and recovery programs conducted in 1973 (Sweitzer 1974) and 1974 (Brock 1976). Inventories of the following areas were conducted as part of a Fisheries Service catalogue series produced between 1973 and 1976: Carmacks area (Walker 1974); Stewart and Pelly sub-basins of the east-central Yukon (Elson 1974); Teslin watershed (Canada, Department of Environment 1973); and the upper Yukon drainage (Brown et al. 1973). A detailed inventory of the mainstem Yukon in the Minto area, conducted in 1975 (Walker 1976), provided valuable information on the distribution and habitat preferences of mainstem chinook populations. The migratory behaviour of adult chinook salmon in the vicinity of the Whitehorse Rapids Dam was studied in 1979 with radio telemetry techniques (Cleugh and Russel 1980). Chinook escapement has been annually monitored at the Whitehorse Fishway since 1959, however, the fishway counts may not reflect escapement into Canadian sections of the basin as a whole because of habitat and migrational disruptions imposed by the hydro facility.

TABLE 2. Estimates of chinook salmon in the upper Yukon River drainage basin as determined from fishwheel tag recovery programs conducted above the Canadian border.

YEAR	POPULATION ESTIMATE	CANADIAN CATCH C-COMMERCIAL D-DOMESTIC S-SUBSISTENCE	SYSTEM ESCAPEMENT (TO NEAREST 100)	SOURCE
1973 a	29,100	C-2,199 S-2,099	24,800	(Sweitzer, 1974) DFO Files
1974 b	11,000* 36,700	C-5,503 S-3,364 D-406	1,700* 27,400	(Brock, 1976) DFO Files
1982 c	36,598	C-8,640 S-7,333 D-435	20,200	
1983 c	47,741	C-13,027 S- 4,800 D- 400	29,500	

* The lower estimate is determined for Petersen disc tags only while the higher estimate is determined from spaghetti tags only excluding catch and recovery data from the Dawson area.

a) Petersen disc tags only

b) Combination of Petersen disc and spaghetti tags

c) Spaghetti tags

Chinook spawning areas in Canada were initially documented in a land use information map series (1:250,000 scale) (Canada, Department of Environment 1973 b). A number of biophysical inventories that included chinook distribution information were conducted by the Department of Renewable Resources of the Yukon Territorial Government (Davies and Ellenton 1980; Davies and Shepard 1981; Davies and Osborne 1983; Pendray 1983). The most recent information on the distribution and abundance of chinook and chum salmon was assimilated into a 1:250,000 map series, to provide background material for the fisheries work group of the Yukon River Basin Study (Ennis et al. 1982 a). This information suggests that chinook salmon are widely distributed throughout all major headwater tributaries in the Yukon River Basin. A considerable amount of fisheries-related information relevant to the study area was compiled in an annotated bibiography produced by Ennis et al. (1982 b). The majority of the fisheries information summarized in this manuscript was originally collected in response to prospective developments which included pipelines, roads, hydroelectric dams and mines. As a result, the state of knowledge is generally confined to transportation and construction corridors and to site-specific studies.

In summary, although a considerable volume of fisheries-related information exists, the status of the Canadian chinook resource has not been investigated at a level which provides the baseline data required for effective management.

1.3 Resource Utilization

The main fisheries for chinook salmon produced in the Yukon River Basin are the Alaskan commercial and subsistence fisheries, and the Canadian commercial, subsistence and domestic fisheries. Catch information for these fisheries is outlined below. In general, the exploitation of chinook stocks has significantly increased in commercial and subsistence fisheries in both Alaska and Canada, although the overall level of exploitation has not been determined. This increase in fisheries catches has important management implications, as noted in section 1.4, Management.

1.3.1 Alaskan Fisheries

Since the Yukon River is a transboundary river, chinook salmon destined for Canadian spawning areas must first migrate through Alaskan waters. An undetermined portion of Canadian bound chinook is intercepted in Alaskan fisheries. An Alaskan commercial chinook fishery began on the lower Yukon in 1918 when 12,239 chinook were landed (Alaska Department of Fish and Game 1981). The chinook catch increased very markedly to 104,822 in 1919, but the fishery declined shortly thereafter, and conflict with a large upriver subsistence fishery resulted in a complete closure between 1925 and 1931. Alaskan commercial chinook catches averaged 63,023 between 1952 and 1961, and 104,371 between 1962 and 1971 (Figure 3). Catches declined in the 1971 - 1976 period because of below average returns and incidental catches in the Japanese high seas fishery (Alaska Department of Fish and Game 1981). Above average chinook returns were recorded between 1977 and 1981 when the average annual Alaskan commercial catch totalled 127,153 (Table 3). Record Alaskan commercial chinook catches of 155,088 and 157,601 were made in 1980 and 1981, respectively.

Alaskan subsistence catches were first recorded in 1920 when 20,000 chinook were harvested (Alaska Department of Fish and Game 1981). Average subsistence catches of 16,250 and 24,378 chinook were recorded in 1962 - 1971 and in 1972 - 1981, respectively (Figure 3). Peak subsistence catches were recorded in the 1979 - 1981 period. A record subsistence catch of 42,724 was landed in 1980 (Table 3).

1.3.2 Canadian Fisheries

A Canadian commercial fishery has operated in the Yukon Territory near Dawson City since 1903. Fishing effort is centered around Dawson, although commercial fishing sites are widely distributed between Tatchun Creek and the Yukon-Alaskan border along the mainstem Yukon, and on the lower reaches of the Pelly River. Prior to 1981, the lack of organized processing and marketing facilities resulted in low commercial catch levels. The 1972 - 1976 average, for example, was 3,194. Substantial catch increases were recorded between 1980 and 1983 when an average commercial catch of 9,818 chinook was recorded (Table 3). The

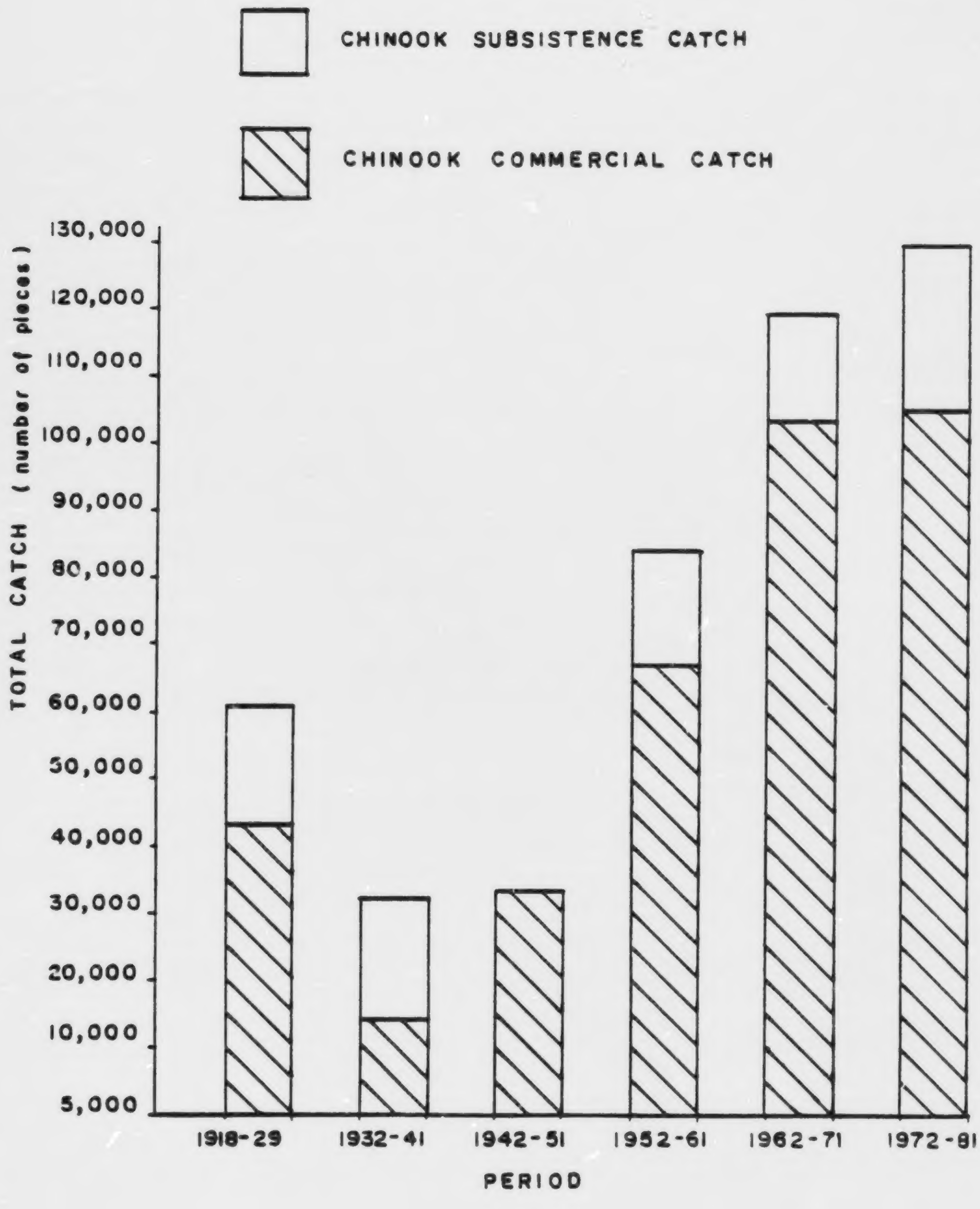

Figure 3 Ten year average commercial and subsistence chinook catches in Alaskan portions of the Yukon River.

TABLE 3. Summary of Canadian and Alaskan gillnet and fishwheel catches of Yukon River chinook salmon: 1960-1983.

Year	Canadian Commercial Catch	Canadian Domestic Catch	Canadian Subsistence Catch	Total Canadian Catch	Alaskan Commercial Catch	Alaskan Subsistence Catch	Total Alaskan Catch	Combined Alaskan and Canadian Catch
1960	4,085		6,965	11,050	67,597			82,962
1961	3,446		10,376	13,822	120,260	21,488	158,779	172,601
1962	4,037		10,500	14,537	94,734	11,110	105,844	120,381
1963	2,283		8,108	10,391	116,994	24,862	141,856	152,247
1964	3,208		6,646	9,854	93,587	16,231	109,818	119,672
1965	2,265		3,115	5,380	118,098	16,608	134,706	140,086
1966	1,942		2,700	4,642	93,315	11,572	104,887	109,529
1967	2,187		3,213	5,400	129,706	16,448	146,154	151,554
1968	2,212		2,900	5,112	106,526	12,106	118,632	123,744
1969	1,640		1,000	2,640	90,223	14,000	104,223	106,863
1970	2,611		2,100	4,711	80,269	13,874	94,143	98,854
1971	3,178		2,800	5,978	110,507	25,684	136,191	142,169
1972	1,769		1,674	3,443	92,840	20,258	113,098	116,541
1973	2,199		2,116	4,315	75,353	24,317	99,670	103,985
1974	5,503	406	3,364	9,273	97,919	19,964	117,883	127,156
1975	3,000	400	2,600	6,000	63,740	13,045	76,785	82,785
1976	3,500	500	1,025	5,025	88,671	17,806	106,477	111,502
1977	4,720	531	2,247	7,498	96,414	17,581	113,995	121,493
1978	2,975	421	2,485	5,881	97,602	27,391	124,993	130,874
1979	6,175	1,200	3,000	10,375	129,056	31,005	160,061	170,436
1980	9,500	3,500	10,000	23,000	155,088	42,724	197,812	220,812
1981	8,593	237	8,129	16,959	157,607	29,690	187,297	204,256
1982	8,640	435	7,333	16,408	123,569	28,158	151,727	168,135
1983	13,027	400	4,800	18,427	147,836*			

* Preliminary estimate

increased commercial catch was attributed to the opening of a fish processing plant in Dawson City in 1981.

In addition to the commercial fishery, chinook salmon are also harvested in subsistence and domestic fisheries. The communities most actively participating in the native subsistence fishery include: Dawson City, Pelly Crossing, Ross River, Stewart Crossing, Mayo, Carmacks, Teslin, and Whitehorse. Approximately 135 native subsistence licenses (food fish permits) were issued in 1983. Catches in this fishery averaged 3,891 between 1972 and 1981 (Table 3). A peak subsistence catch (10,000 chinook) was harvested in 1980.

Domestic fishing licenses are issued to non-native people. Approximately 20 individuals participate in this fishery, although catches are low. In the past decade, both native subsistence and domestic catches have generally increased (Table 3).

1.4 Management

The management of transboundary salmon stocks (salmon which are produced in one country, but which spend part of their life cycle in another) is particularly difficult in the absence of a formal salmon interception agreement. In the case of chinook salmon produced within Canadian sections of the Yukon River Basin, the aspirations of the Department of Fisheries and Oceans towards increasing stock levels have not been realized. This has resulted from the combination of current interception levels in Alaska and the lack of a joint management plan. Canada has very limited control over the magnitude of chinook returns to the upper Yukon River watershed.

As a result of increased demand for the chinook resource, the Department of Fisheries and Oceans revised the liberal fishing pattern that existed prior to 1982, when an open period of six days per week was in effect and unlimited effort was permitted. Licenses now are limited in both the commercial and domestic fisheries, and open periods are more dependent upon run strength. The management priorities of the Department of Fisheries and Oceans in terms of allocation of the chinook resource are as follows:

1. conservation (maintaining adequate escapement stocks);
2. native food fish requirements;
3. commercial and recreational fisheries.

Despite the past and present management actions, the escalation of chinook catches in both the Yukon and Alaska is a cause for concern, especially in the absence of consistent escapement monitoring and common escapement goals. Recent increases in catch levels may have been made at the expense of spawning escapements.

2.0 SPAGHETTI TAGGING PROGRAM 1982-1983

As indicated previously, the spaghetti tagging and radio-tagging programs are described separately. For the spaghetti tagging program, section 2.1 below describes the materials and methods used, and the results and discussion of the tagging work are included in section 2.2.

2.1 Materials and Methods

2.1.1 Capture Techniques

Three methods were used to capture fish, as follows:

1. trapping by fishwheel (see Appendix I and Plate 1)

2. gillnetting with small mesh gillnets

3. seining

These methods are described briefly below.

2.1.1.1 Fishwheel Design and Placement

This section provides summary information of fishwheel design. Additional details of fishwheel design are presented in Appendix I. The fishwheels were of a two-basket variety, designed and prefabricated at the Department of Fisheries and Oceans shop in Whitehorse and later assembled on-site. The baskets and supporting structures were constructed with 3.8 cm x 8.9 cm milled lumber and covered with a stucco wire mesh, the mesh openings measuring 5.1 x 5.1 cm. A high density polyethylene mesh material (L-70 Vexar) with a mesh opening of 4.5 x 4.5 cm was experimentally used in 1983. Both fishwheels rotated on axles constructed from timbers measuring 22 x 22 cm. Axle supports were designed for variable fishing depth. Approximately 0.9 m of depth adjustment was possible. The largest fishwheel was capable of fishing an area 3 m deep x 2.4 m wide.

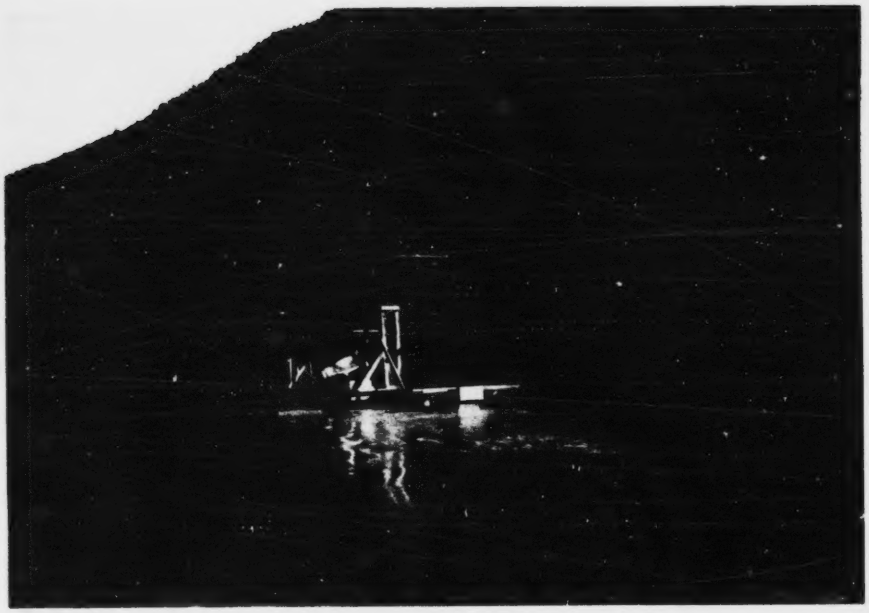

Plate 1 Fishwheel located 15 km upstream of the international border on the Yukon River. This fishwheel operated at speeds of one to six revolutions per minute.

Plate 2 The largest chinook were transferred from the fishwheel live-box to a fish tote filled with water.

The substructure of each fishwheel consisted of two pontoon-type rafts framed with 3.8 cm x 19.0 cm milled lumber and decked with plywood. Deck dimensions of each pontoon were approximately 0.5 m x 7.6 m (20% longer for the larger wheel). The two pontoons were held apart by two 30.9 cm x 8.9 cm cross members which also served as walkways. These were located fore and aft of the fishwheel baskets. Floatation was provided by ten 200 litre (45 gallon) steel barrels filled with polyurethane foam. Five barrels were positioned under each pontoon. Live-boxes were constructed from plywood and aluminum grates (5.1 cm spacing between bars) which permitted a continuous flow of water over the captive fish. As the fishwheel baskets rotated (one to six r.p.m.), U-shaped slides built into each basket deflected the fish into the live-boxes (Plate 2).

In 1982, two fishwheels where constructed and positioned on the Yukon River in locations 7 and 12 km upstream from the Yukon/Alaska border. In 1983, three fishwheels were positioned in locations 12, 15 and 89 km above the Alaska border (Figure 1). The lower fishwheel sites permitted tag application downstream from all Canadian fishing activities; however, the fishwheel located at km 89 was also located below the majority of the commercial fishing activity.

Prior to positioning the fishwheels, prospective sites (back eddies) were sounded using either a Furuno model 200 depth sounder or a five meter length of rebar[1]. This was done to determine if adequate fishing depths could be maintained throughout the typical low flow regime of late summer. Once a suitable site was chosen, the fishwheel was positioned at the upstream limit of the eddy where the mainstem current was of sufficient force to turn the wheel. The fishwheel was secured in position with 0.95 cm diameter steel cables and several large polypropylene ropes, and log booms were used to hold the fishwheel out from and parallel to the shoreline. A lead (stucco wire and/or seine material) was placed obliquely from shore to the midpoint of the shoreward pontoon so that fish moving close to the bank would be directed towards the fishwheel.

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[1] Rebar is a common term for steel rod used to reinforce concrete.

During the course of operation, the fishwheels were checked a minimum of three times daily, and more frequent checks were made during peak migration in order to minimize overcrowding and holding time. Repositioning of the fishwheels was frequently required to compensate for fluctuating water levels.

2.1.1.2 Netting

Small mesh gillnets (10.2 cm - 11.4 cm stretched measure) were used as set nets or drift nets as alternative capture techniques during the 1982 field season. Set net dimensions were 30 m (length) x 2.2 m (depth), although the full length of the net was not always fished. Set nets were positioned in two small eddies located near the lower tagging site. A two-person tagging crew manned each net. When a fish was caught by the net (this was evident from bobbing cork(s) along the corkline), the tagging crew pulled alongside the net in a small boat, removed the fish from the net, tagged, sampled (see subsection 2.1.5, Biological Sampling), and released the fish.

Drift nets (30 m in length x 2.4 m in depth) were fished along gently sloping gravel bars and in mainstem areas. Bar drifts were accomplished with one person walking the shoreline with a rope attached to one end of the net while two people attended the other end from the boat. Mainstem drifts were conducted by two people using a boat, drifting with the current for a period of one to five minutes. Drift netting was of greater importance in the verification of mainstem spawning areas than in live-capturing chinook for tagging.

Seine nets were used to capture adult fish as well as juveniles. The adult seine measured 61 m (length) x 6.1 m (depth) with a 7.6 cm mesh, and the juvenile seine measured 30 m (length) x 1.7 m (depth) and a 0.64 cm mesh. The netting procedure involved one person positioned on shore and two people stationed in the attending boat. The seine net was drawn out into the current, drifted for approximately two minutes, looped into a hook shape, and pulled back into shore. The net was then drawn up on shore.

2.1.2 Application of Spaghetti Tags

The spaghetti tags used in this study consisted of consecutively numbered, fluorescent orange, hollow PVC tubing (size 13 - approximately 2.0 mm in diameter). Each tag had DFO identification and measured approximately 30 cm in length. The spaghetti tags used were obtained from Floy Tag & Manufacturing Inc., Seattle, Washington.

Salmon captured by the techniques outlined in section 2.1.1 were transferred by dipnet to a tagging box or, in the case of large chinook, to a fish tote (1 m x 0.5 m x 0.5 m) filled with water. Spaghetti tags were applied with a 15 cm needle-like applicator which was inserted through the musculature beneath the dorsal fin. The ends of the spaghetti tag were knotted tightly together with a single overhand hitch. During the application of tags, biological sampling was also conducted as described in subsection 2.1.5. In total, the tagging and sampling procedure took from 25 seconds to one minute to complete.

2.1.3 Tag Recovery

Recapture of tagged chinook salmon was made primarily in commercial, subsistence, and domestic set gillnet fisheries, although recoveries were also made in the sports fishery. Mesh sizes used in the gillnet fisheries were variable, ranging from 11.4 cm to 22.9 cm (stretched measure). Additional tag recoveries were made in a commercial fishwheel located near Dawson City. In 1982, the fishing period in both the commerical and domestic fisheries was restricted to five days per week because of reduced run strength. Fishing was permitted six days per week during the 1983 season. In both years, time constraints were not imposed on the native subsistence fishery.

To promote the return of tags recaptured in the various fisheries, lotteries were established. Ten $100.00 prizes were offered in 1982, while two $100.00 prizes were offered in 1983. Each tag or tag number returned with information regarding the date and location of capture was counted as an entry. Additional catch and tag recovery information from the commercial and subsistence fisheries was obtained from catch cards which were distributed to all fishermen. Posters advertising the draw were displayed in DFO offices in Whitehorse, Dawson City and Haines Junction, and in Post Offices and Yukon Territorial Government Fish and Wildlife Branch offices. A list of draw winners was printed in two Whitehorse newspapers, the Whitehorse Star and the Yukon News.

Tag recoveries were also made by field personnel during spawning ground surveys (see section 2.1.4, below). Recapture techniques involved the use of adult beach seines, as described previously, and/or gaffs.

2.1.4 Gross Escapement and Spawning Surveys

Gross escapement was defined as the number of fish that theoretically migrate to spawning grounds. In this study, gross escapement was determined from population estimates and recorded catch information with the following equation:

Gross Escapement = total population estimate - total recorded catch.

The total recorded catch includes all Canadian commercial, domestic, sports, and native subsistence catches in the upper Yukon River Basin.

A selected number of chinook spawning areas were surveyed with aerial and ground survey techniques in 1982 and 1983. Aerial surveys were conducted with a Cessna 185 floatplane at an altitude of 50 to 100 m. Surveys were flown at an airspeed of approximately 148 $km.h^{-1}$ depending upon terrain features, weather conditions (particularly the wind direction), and safety factors. In 1983, all aerial surveys were conducted in conjunction with the final radio-tracking surveys (see section 3.1.6). For this reason, the timing of these surveys did not necessarily coincide with the peak spawning period. Direct visual counts were made by two observers, one on each side of the aircraft. The total survey counts were either added together or compared, depending on survey conditions.

Ground surveys were conducted by boat or on foot. A selected number of ground surveys were conducted between August 18 and September 8, 1982. A search of mainstem chinook spawning areas was conducted from August 9 to 26, 1983. The survey area was located between Tatchun Creek and the Selwyn River. Field personnel confirmed the presence of mainstem spawners by drifting gill nets (see section 2.1.1.2) through suspected spawning areas. Spawning was verified by the presence of chinook in an advanced state of maturity (expulsion of sex products).

Chinook escapement into the upper Yukon drainage above Whitehorse was monitored at the Whitehorse Fishway, which contains a fish counting structure operated by DFO personnel. Annual fish passage data were obtained for the period 1958 to 1983 (Appendix 7).

In addition to the preceding surveys, aerial surveys of a number of Canadian index streams were conducted in 1983 by the Alaska Department of Fish and Game (Appendix 3). The stream systems surveyed and the aerial survey dates were as follows:

System	Date Flown
Big Salmon River	August 14
Little Salmon River	August 14
Nisutlin River	August 15
Wolf River	August 16
Morley River	August 16
Swift River	August 16
Jennings River	August 16
Gladys River	August 16
Upper Teslin River	August 16
Tincup Creek	August 17

2.1.5 Biological Sampling

Baseline biological data were collected as part of an ongoing DFO sampling program to obtain information on chinook salmon size, sex and age composition, at the following three locations:

1. the tagging sites;

2. Han Fisheries processing plant in Dawson City;

3. selected spawning grounds.

At the tagging sites, fork length was determined to the nearest centimeter with a meter stick attached to the tagging box. Sex was determined by visual examination of external morphological characteristics. Male chinook were identifiable by the presence of a large kype, while females were identified by the presence of distended urogenital papillae. Two scales were removed from the area located two rows above the lateral line along an imaginary line extending from the posterior margin of the dorsal fin to the anterior edge of the anal fin .

At Han Fisheries in Dawson City, a random sample of the commercial catch was measured for post-orbital hypural length using a one-meter hypural stick. Weight was determined (to the nearest ounce) with a sixty pound capacity Detecto dial scale and later converted into kilograms. Five scales were removed from each fish for age analysis.

Spawning ground samples were measured for fork and hypural length. Carcasses were dissected to determine spawning success (ie. as indicated by the presence of retained sex products). Ten scales were removed for age analysis. This greater number of scales was necessary because of the high rate of scale resorption common to spawning populations.

Scale samples were cleaned and stored on numbered gum cards. Scales impressions were made on acetate slides using a Model C Carver scale press located in the DFO office in Whitehorse. Ages were determined using standard techniques.

2.1.6 Population Estimates

Population estimates were calculated from the tag and recapture information and commercial catch statistics collected downstream of the first major tributary (Stewart River). Catch and tag recovery information from below the Stewart River was the most reliable information available. Commercial fishing activity was most constant in the Dawson City area and daily catch records were checked and collected on a weekly basis by fisheries personnel. Catch information below the Stewart River reduced the statistical bias of retrieving tags from an unknown sample size. Tag returns from other areas were most useful in determining catch distribution. The population estimates were calculated in terms of the total number of chinook migrating into the upper Yukon River Basin.

Population estimates were determined with the Adjusted Petersen Estimate, which gives an unbiased estimate in most situations (Ricker 1975), and by the Schaefer Estimate for stratified populations, which stratifies the time of marking and recovery into a series of units, each partially distinct from adjacent units. The Schaefer Estimate reduces the bias of the standard Petersen estimate if the original marking and the sampling for recoveries are selective (Ricker 1975). The Schaefer Estimate was used in 1982 only.

The adjusted Petersen and Schaefer formulae are as follows:

Adjusted Petersen Estimate

$$N = \frac{(M + 1)(C + 1)}{R + 1}$$

Where:

N = size of population

M = number of fish marked

C = total commercial catch examined for tags

R = number of recaptured tags in the sample

Schaefer Estimate

$$N = \Sigma Nij = \Sigma \left(Rij + \frac{Mi}{Ri}\,\frac{Cj}{Rj}\right)$$

Where:

N = size of population

Mi = number of fish tagged in ith period of tagging

Cj = number of fish examined in the jth period of recovery

C = Σ Cj, total number examined

Rij= number of fish marked in ith tagging period which are recaptured in the jth recovery period

Ri = total recapture of fish tagged in the ith period

Rj = total recaptured during the jth period

The 95% confidence limits (r) were determined for the number of recaptures (R). For R values less than 50, the confidence limits were determined from a table presented in Ricker (1975). For R values greater than 50, confidence limits were determined by Pearson's formula, as follows:

$$95\% \text{ confidence limits} = x + 1.92 \pm \sqrt{x + 1.0} \quad \text{where } x = R$$

The lower and upper limits for the r values were then applied to the Adjusted Petersen formula.

2.1.7 Exploitation Rates

Exploitation rates were determined in two ways. In 1982 and 1983, total exploitation rates were determined from tag returns from all sources. In 1982, weekly exploitation rates were determined for the Dawson area commercial fishery from tag returns below the Stewart River. The exploitation rates were determined with the following formulae:

$$\text{Total Exploitation Rate} = \frac{\text{number tags returned}}{\text{number tags applied}} \times 100\%$$

$$\text{Weekly exploitation rate in Dawson} = \frac{\text{number salmon caught commercially}}{\text{estimated number of fish available for capture as determined by the Schaefer estimate}} \times 100\%$$

Adjustments to the exploitation rates were made for unreported tag returns, but not for tagging mortality or tag loss since these were difficult to quantify.

2.1.8 Migration Rates

Migration rates were determined from spaghetti tag recovery information with the following formula:

$$\text{Migration Rate} = \frac{\text{distance travelled (km)}}{\text{elapsed time (days)}}$$

The sum of the migration rates of individual fish were averaged to give an overall rate. Migration rates were calculated in $km.day^{-1}$ rather than $km.h^{-1}$ because the precise time of the recaptures was not known.

2.2 Results and Discussion

2.2.1 Tag Application

In 1982, 265 chinook salmon were tagged with spaghetti tags between July 13 and August 30; of these, 256 chinook were live-captured by fishwheel and nine were live-captured with small mesh set gillnets. In 1983, 1266 chinook salmon were tagged with spaghetti tags between July 1 and September 12; all were live-captured by fishwheel. Spaghetti tags were also applied to six incidental species live-captured during fishwheel operation (see Appendix 3).

During the 1982 program, drift gillnetting and beach seining proved to be inappropriate methods for live-capturing chinook, partly because they were labour intensive and they resulted in high gear loss. In addition, drift gillnetting could be an unacceptable method of live-capturing Yukon chinook salmon because of the potential for physical injuries and high stress levels in the captured fish. The fishwheels were a more effective live-capture technique in 1983 than in 1982; therefore, netting techniques were not employed during the 1983 season. Increased live-capture success in 1983 was more attributable to migration behaviour than to increased run strength: the high water during the 1983 season appeared to have displaced migrating chinook into shallower water where they were more vulnerable to the shore-based fishwheel gear.

Of the live-capture techniques used, the fishwheels minimized the possibility of physical injury. The fishwheel holding pens had an adequate supply of well oxygenated water, which appeared to reduce the trauma of live-capture and confinement. In addition, holding time was minimized as much as manpower constraints permitted, and the fishwheels were checked a minimum of three times daily. During the peak of the run, the fishwheels were checked more frequently, and occasionally, fishwheel-related activities occurred continuously throughout the day.

2.2.2 Tag Recovery and Catch Information

Of the 265 spaghetti tags applied in 1982, 58 were recovered in the commercial fishery located below the Stewart-Yukon confluence. An additional 41 tags were recovered upstream of the Stewart-Yukon confluence. The small sample size in 1982 precluded any quantitative comparisons between tag recovery and sub-basin location.

In 1983, 315 of the 1266 spaghetti tags applied were recovered in the commercial fishery located downstream of the Stewart-Yukon confluence. Eight spaghetti tags were recovered in the same area by native subsistence fishermen and two tags were recovered downstream of the study area at Eagle, Alaska. An additional 128 tags were recovered upstream of the Stewart-Yukon confluence (Table 3). This total includes 75 (58.6%) recaptures in the native subsistence fisheries, and 42 (32.8%) recaptures in commercial fisheries located above the Stewart-Yukon confluence. Five (3.9%) tagged chinook passed through the Whitehorse Fishway, and six (4.7%) tags were recovered on the spawning grounds (Table 4).

Based on tag return information, native subsistence fisheries recaptured a significant number of tags above the Stewart-Yukon confluence. The various native communities or tributaries where these communities are located were ranked in the following order of importance:

- Carmacks (mid-Yukon mainstem)
- Pelly sub-basin (Pelly Crossing and Ross River)
- Stewart sub-basin (Stewart Crossing and Mayo)
- Moosehide Village and Dawson City area
- Teslin sub-basin (Johnson Crossing and community of Teslin)
- Minto (mid-Yukon mainstem)
- Fort Selkirk (lower Yukon mainstem)
- Whitehorse (upper Yukon mainstem).

A summary of commercial and subsistence chinook catches is presented in Table 4. The commercial catch in the Dawson area (below Stewart-Yukon confluence) increased from 7,979 in 1982 to 12,539 in 1983. The 1983 commercial catch was the highest chinook harvest recorded to date.

Twenty-two fish were tagged as incidental species in 1982 and 1983 (Appendix 2). Three of these fish were recaptured in Alaskan fisheries. The most notable recapture involved a humpback whitefish that was recaptured approximately 400 km downstream of the tagging site almost nine months after tag application.

Table 4 Summary of spaghetti tag returns by location and fishery: 1983.

a) Spaghetti tag returns below the Stewart-Yukon confluence.

Sub-basin	Commercial Fishery		Native Fishery		Spawning Areas		Percent
	Number	%	Number	%	Number	%	
Yukon Mainstem - Canadian Alaskan border to Stewart-Yukon confluence	315	96.9	10*	3.1	0	0	100.00

b) Spaghetti tag returns above the Stewart-Yukon confluence.

Sub-basin		Commercial Fishery		Native Fishery		Spawning Areas		Percent
		Number	%	Number	%	Number	%	
Yukon Mainstem	- Lower[a]	21	16.4	2	1.6	-	-	18.0
	- Middle[b]	20	15.6	33	25.8	5	3.9	45.3
	- Upper[c]	-	-	3	2.3	6**	4.7	7.0
Stewart		-	0.80	8	6.3	-	-	7.1
Pelly		-	-	25	19.5	-	-	19.5
Teslin		-	-	4	3.1	-	-	3.1
White		-	-	-	-	-	-	-
Total		42	32.8	75	58.6	11	8.6	100.0

[a] Yukon River from Stewart-Yukon confluence to Fort Selkirk

[b] Yukon River from Fort Selkirk to Hootalinqua; includes Big Salmon, Little Salmon, and Nordenskoid Rivers, and Tatchun Creek

[c] Yukon River upstream of Hootalinqua

* Two of these tags were recovered in a substitute fishery at Eagle, Alaska

** Includes five tagged fish through the Whitehorse Fishway and one tag return from the Takhini River

2.2.3 Population Estimates

Chinook population estimates were determined from commercial catch and tag return information from the Canadian section of the Yukon River below the Stewart-Yukon confluence. Fifty-eight of the 265 spaghetti tags applied in 1982 were recovered in this area from a commercial catch of 7,979 chinook. Of the 1,266 spaghetti tags applied in 1983, 315 were recovered from commercially caught chinook below the Stewart River. A commercial catch of 11,906 chinook was examined for tags. Chinook population estimates were calculated as follows (using the Schaefer and Petersen formulae described previously in section 2.1.6):

A) Schaefer Estimate: 1982*

$$N = \Sigma Nij = \Sigma (Rij + \frac{Mi}{Ri} \cdot \frac{Cj}{Rj})$$

i) using combined male and female

$N = 38{,}323$

ii) using male and female separated

N = male + female

$N = (16{,}643) + (18{,}136)$

$N = 34{,}779$

B) Adjusted Petersen Estimate: 1982

$$N = \frac{(M + 1)(C + 1)}{(R + 1)}$$

i) using combined male and female

$$N = \frac{(265 + 1)(7{,}979 + 1)}{(57 + 1)}$$

$N = 36{,}598$

The 95% confidence limits for the number of recaptures (R) were calculated as follows:

$r = x + 1.92 + 1.96 \pm \sqrt{x} + 1.0$ where: $x = 57$

---

* The Schaefer Estimte was not calculated in 1983.

The lower and upper limits of r were then substituted into the Adjusted Petersen Formula. The results were as follows:

Lower Limit: N = 28,359
Upper Limit: N = 47,181

ii) using male and female separated

N = male estimate + female estimate
N = 16,190 + 18,453
N = 35,363

The 95% confidence limits were as follows:

Lower Limit: N = 24,659
Upper Limit: N = 52,739

C) Adjusted Petersen Estimate: 1983

i) using combined male and female

$$N = \frac{(1{,}266 + 1)(11{,}906 + 1)}{(315 + 1)}$$

N = 47,741

The 95% confidence limits were as follows:

Lower Limit: N = 42,888
Upper Limit: N = 53,482

ii) using male and female separated

N = male estimate + female estimate
N = 25,189 + 21,650
N = 46,839

The 95% confidence limits were as follows:

Lower Limit: N = 39,942
Upper Limit: N = 54,954

In 1982, both the Schaefer and the Adjusted Petersen estimates were used, and for comparative purposes, the male and female components of the tagged and recovery samples were analyzed separately and in combination. Consequently, four population estimates were determined, all of which were similar ranging from 34,779 to 38,323 chinook. The Adjusted Petersen Estimate for combined sexes (36,598 chinook) was thought to be the most representative 1982 population estimate. All of the 1982 population estimates were based on a small sample of tagged chinook, which accounts for the wide range in the 95% confidence limits.

The 1982 chinook population estimates were similar to population estimates determined in 1973 (Sweitzer 1974) and 1974 (Brock 1976). The 1973 estimate totalled 29,054 chinook while an estimate of 36,719 chinook was determined in 1974. The 1974 estimate excluded catch and recovery data from the Dawson area and relied on recapture data above the first major tributary (Stewart River). This could have resulted in gross errors had the tags been retrieved from an unknown sample size. The 1974 estimate was recalculated to 22,142 by using catch and tag recovery information from the Dawson area.

The 1982 chinook return was thought to be the lowest in a number of years. Chinook escapements into index areas surveyed by the Alaska Department of Fish and Game were approximately 1/3 of those observed in 1980 and 1981 (Appendix 3). The poor 1982 chinook return to Canadian portions of the Yukon River Basin may have resulted from heavy fishing pressure in Alaskan portions of the drainage, and from a record incidental chinook harvest (704,000) in the Japanese high seas mothership fishery in 1980 (Appendix 4). The Japanese catch consisted primarily of four year old chinook which usually return to spawn at five or six years of age. Approximately 30% (93,600 chinook) of the western Alaskan component of the Japanese catch was thought to have originated from the Yukon River drainage (Appendix 4; Alaska Department of Fish and Game 1981).

In 1983, only the Adjusted Petersen Estimate was used. Again, the male and female components were analyzed separately and in combination. The population estimates ranged from 46,839 (sexes separated) to 47,741 (sexes combined). The 95% confidence limits for the latter estimate ranged from 39,942 to 54,954. The 1983 chinook population estimates exceeded all previous estimates determined from Canadian tagging programs (Table 2); however, these population estimates were not reflected by the available spawning escapement data, which suggested that chinook returns were considerably stronger in 1980 and 1981 than in 1983, and that the 1983 spawning run did not represent the optimum escapement to areas above the Alaska/Yukon border.

2.2.4 Exploitation Rates

The chinook exploitation rate in the Dawson area commercial fishery was 21.9% in 1982 and 24.9% in 1983. Weekly chinook exploitation rates for 1982 ranged from a low of 14.0% to a high of 23.8% based on weekly Schaefer Estimates (Figure 4).

The 1983 exploitation rate for Dawson area commercial fishery exceeded the rate determined for 1982, however, the overall exploitation rate for the upper Yukon River Basin was identical (35.1%) for both years. The actual exploitation of chinook salmon probably exceeded the calculated rates because of unreported tag recoveries and possible dropout of tagged fish. The extent of unreported tag recoveries was unknown, but the total probably represented a significant number of tags. In view of the possible unreported recoveries and net dropouts, the exploitation of chinook salmon could be expected to exceed 35% and may approach a rate of 40-45%.

By comparison, a chinook exploitation rate of 10.7% was determined in a tag-recovery (Petersen disc tags) conducted in 1973 (Sweitzer 1974), and exploitation rates ranging from 24.6 to 31.9% were determined from a similar tagging program using spaghetti and Petersen disc tags (Brock, 1976).

2.2.5 Biological Sampling

2.2.5.1 Age Composition

Totals of 702 and 2,108 chinook were sampled in 1982 and 1983, respectively. The age compositions of samples taken at a tagging site, the commercial fishery, and on the spawning grounds, and of fish for which tags were returned, are shown in Tables 5 and 6. The predominant age groups, by sample source, were as follows:

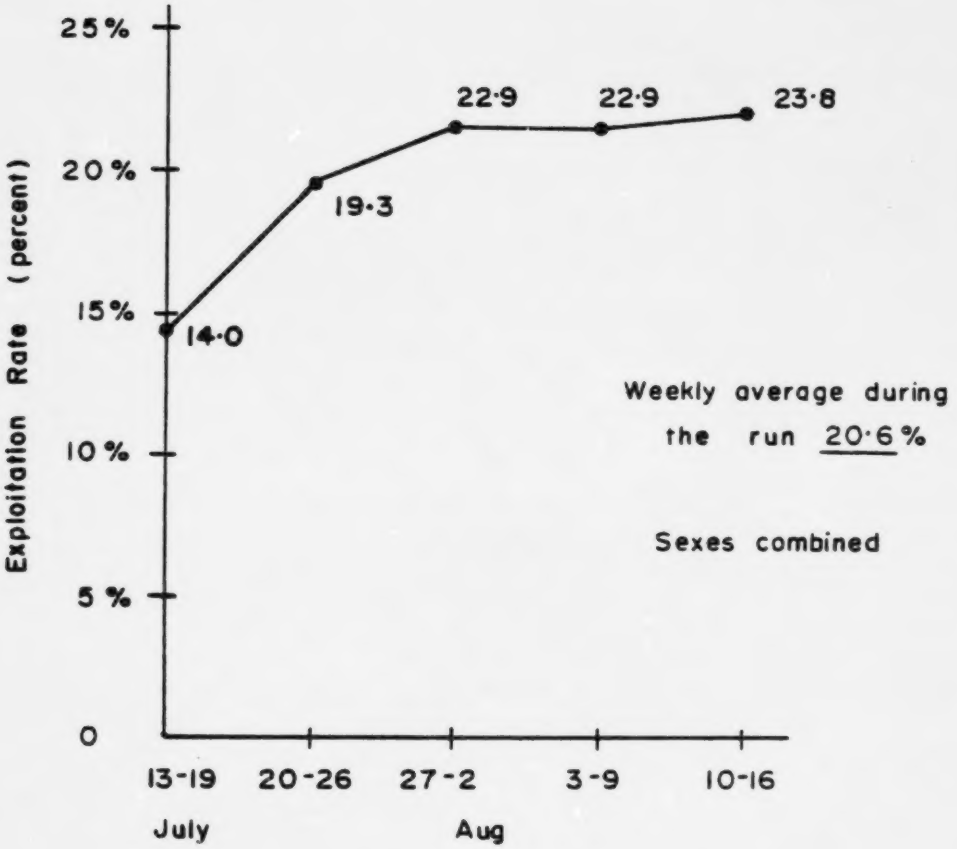

Figure 4 Weekly chinook exploitation rate in Dawson area commercial fishery, 1982.

TABLE 5. Comparison of the age and sex composition of Yukon River chinook salmon from the various sampling location in 1982.

TAGGING SITE

A. AGE	TOTAL	MALE		FEMALE		COMBINED
	N	NUMBER	%	NUMBER	%	%
4_2	49	41	34.5	8	6.7	41.2
5_2	32	20	16.8	12	10.1	26.9
6_2	23	7	5.9	16	13.4	19.3
6_3	2	2	1.7	0	0	1.7
7_2	6	3	2.5	3	2.5	5.0
7_3	5	0	0	5	4.2	4.2
8_3	2	0	0	2	1.7	1.7
TOTAL	119	73	61.4	46	38.6	100.0

COMMERCIAL FISHERY

B. AGE	TOTAL	MALE		FEMALE		COMBINED
	N	NUMBER	%	NUMBER	%	%
4_2	11	11	4.1	0	0	4.1
5_2	51	39	14.4	12	4.4	18.8
5_3	2	2	0.7	0	0	0.7
6_2	145	50	18.4	95	35.1	53.5
6_3	2	2	0.7	0	0	0.7
7_2	40	14	5.2	26	9.6	14.8
7_3	14	3	1.1	11	4.1	5.2
8_3	6	0	0	6	2.2	2.2
TOTAL	271	121	44.6	150	55.4	100.0

SPAWNING GROUNDS

C. AGE	TOTAL	MALE		FEMALE		COMBINED
	N	NUMBER	%	NUMBER	%	%
4_2	2	0	0	2	1.7	1.7
5_2	17	13	11.1	4	3.4	14.5
6_2	75	28	23.7	47	39.8	63.5
7_2	13	4	3.4	9	7.6	11.0
7_3	11	3	2.5	8	6.8	9.3
TOTAL	118	48	40.7	70	59.3	100.0

TAG RETURNS

D. AGE	TOTAL	MALE		FEMALE		COMBINED
	N	NUMBER	%	NUMBER	%	%
4_2	17	15	31.2	2	4.2	35.4
5_2	14	8	16.6	6	12.5	29.1
6_2	11	5	10.4	6	12.5	22.9
6_3	1	1	2.1	0	0	2.1
7_2	3	1	2.1	2	4.2	6.3
7_3	1	0	0	1	2.1	2.1
8_3	1	0	0	1	2.1	2.1
TOTAL	48	30	62.4	18	37.6	100

TABLE 6. Comparison of the age and sex composition of Yukon River chinook salmon from the various sampling locations in 1983.

A) TAGGING SITE

	TOTAL	MALE		FEMALE		
AGE	N	NUMBER	%	NUMBER	%	COMBINED
4_2	51	47	8.2	4	0.7	8.9
5_2	208	174	30.4	34	5.9	36.3
5_3	3	3	0.5	0	0.0	0.5
6_2	238	106	18.5	132	23.1	41.6
6_3	35	30	5.2	5	0.9	6.1
7_2	14	6	1.0	8	1.4	2.4
7_3	23	7	1.2	16	2.8	4.0
8_3	1	1	0.2	0	0.0	0.2
TOTAL	573	374	65.2	199	34.8	100.0

B) COMMERCIAL FISHERY

	TOTAL	MALE		FEMALE		
AGE	N	NUMBER	%	NUMBER	%	COMBINED
4_2	7	5	0.9	2	0.4	1.3
5_2	53	42	7.8	11	2.0	9.8
5_3	2	2	0.4	0	0.0	0.4
6_2	329	139	25.8	190	35.3	61.1
6_3	25	21	3.9	4	0.7	4.6
7_2	42	19	3.5	23	4.3	7.8
7_3	73	28	5.2	45	8.3	13.5
8_3	8	5	0.9	3	0.6	1.5
TOTAL	539	261	48.4	278	51.6	100.0

C) SPAWNING GROUNDS

	TOTAL	MALE		FEMALE		
AGE	N	NUMBER	%	NUMBER	%	COMBINED
4_2	1	1	1.3	0	0.0	1.3
5_2	8	4	5.1	4	5.1	10.2
5_3	0	0	0.0	0	0.0	0.0
6_2	50	14	17.9	36	46.2	64.1
6_3	1	1	1.3	0	0.0	1.3
7_2	14	0	0.0	14	17.9	17.9
7_3	4	2	2.6	2	2.6	5.2
8_3	0	0	0.0	0	0.0	0.0
TOTAL	78	22	28.2	56	71.8	100.0

D) TAG RETURNS

	TOTAL	MALE		FEMALE		
AGE	N	NUMBER	%	NUMBER	%	COMBINED
4_2	9	8	4.1	1	0.5	4.6
5_2	80	69	35.6	11	5.7	41.3
5_3	1	1	0.5	0	0.0	0.5
6_2	81	42	21.7	39	20.1	41.8
6_3	12	8	4.1	4	2.1	6.2
7_2	4	1	0.5	3	1.5	2.0
7_3	7	3	1.5	4	2.1	3.6
8_3	0	0	0.0	0	0.0	0.0
TOTAL	194	132	68.0	62	32.0	100.0

Year	Sample Source	Predominant Age Group	Percent Composition
1982	tagging site	4 & 5	68.1
	spawning grounds	5 & 6	78.0
	Han Fishery	5 & 6	73.7
	tag returns	4 & 5	64.5
1983	tagging site	5 & 6	84.5
	spawning grounds	6	65.4
	Han Fishery	6	65.7
	tag returns	5 & 6	89.8

The age structure of the 1983 chinook return was older than the 1982 return. However, in both years the older age classes dominated the spawning ground sample.

The majority of the scales aged in 1982 and 1983 had one freshwater annulus (91.5% and 85.9%, respectively). The remainder (8.5% in 1982; 14.1% in 1983) had two freshwater annuli (Tables 5 and 6).

These age composition data were similar to the age data obtained in previous programs, the results of which are summarized as follows:

	Age Class Present Composition					
Source	III	IV	V	VI	VII	Comments
Sweitzer (1974)	0	7.3	45.1	37.8	9.8	n = 164
Elson and Steigenberger (1977)	1.2	25.6	56.1	15.9	1.2	n = 182; captured in 1976 by gillnet (15.2 cm and 20.3 cm stretched mesh size) near Fresno Creek
Brock (1976)	9.0	68.5	18.0	4.5	0	n = 490; the high proportion of 3 year olds, which seems unlikely, may have resulted from errors in age analysis, related to the resorption of the outer annulus, as is common in spawning populations

2.2.5.2 Sex Composition

The sex composition at the different sampling sites is presented in Table 7. Fishwheel catches and tag returns had the highest incidence of male chinook, followed by samples taken at the Han Fishery and on the spawning grounds. The high incidence of males in the tag return sample was expected since a higher percentage of males were tagged. The selective nature of the fishwheels towards small male chinook was observed in previous Yukon River tagging programs (Sweitzer 1974; Brock 1976) and on the Taku River (Alaska Department of Fish and Game 1952; 1953). The incidence of male chinook at the Han Fishery (49.0% - two year mean) (Table 7) was significantly less than in gillnet samples obtained in 1973 (86.0%) and in 1975 (93.0%) (Walker 1976). This difference was attributed to a recent shift from small gillnet mesh sizes to large mesh sizes (20.3 - 21.6 cm) in the Dawson commercial fishery. The large mesh sizes are strongly selective for the larger female chinook which are most abundant in the 6_2 age class*. This was quite apparent in the Han Fishery samples, where 35.1% in 1982 and 35.3% in 1983 were 6_2 females (Tables 5 and 6).

2.2.5.3 Length and Weight

Fork length frequencies of male and female chinook are illustrated in Figures 5 and 6, respectively, for the 1982 sample, and in Figures 7 and 8, respectively, for the 1983 sample. Median fork lengths (mm) by year, sex, and recapture source are summarized as follows:

	1982		1983	
Source	Male	Female	Male	Female
Tagging Site (Fishwheels)	688.4	784.5	787.3	904.4
Han Fisheries	978.1	968.5	969.0	943.6
Spawning Ground	906.8	896.3	933.5	928.1
Tag Returns	661.8	861.3	806.0	905.1

---

* Age class designations show the age along with a subscript indicating the length of time spent in fresh water. A subscript 2 indicates one full year of freshwater residency. A subscript 1 would indicate the fish went to sea prior to one full year in freshwater.

TABLE 7. Sex composition of Yukon River chinook salmon in 1982 and 1983.

Location	Percent Male		Sample Size	
	1982	1983	1982	1983
Fishwheels*	64.8	68.7	247	1266
Tag Returns	63.4	69.7	93	435
Han Fishery	46.7	51.2	317	730
Spawning Grounds	43.5	37.5	138	112

* Fishwheel sample (tagging sites) include a small number of gillnet tagged chinook in 1982.

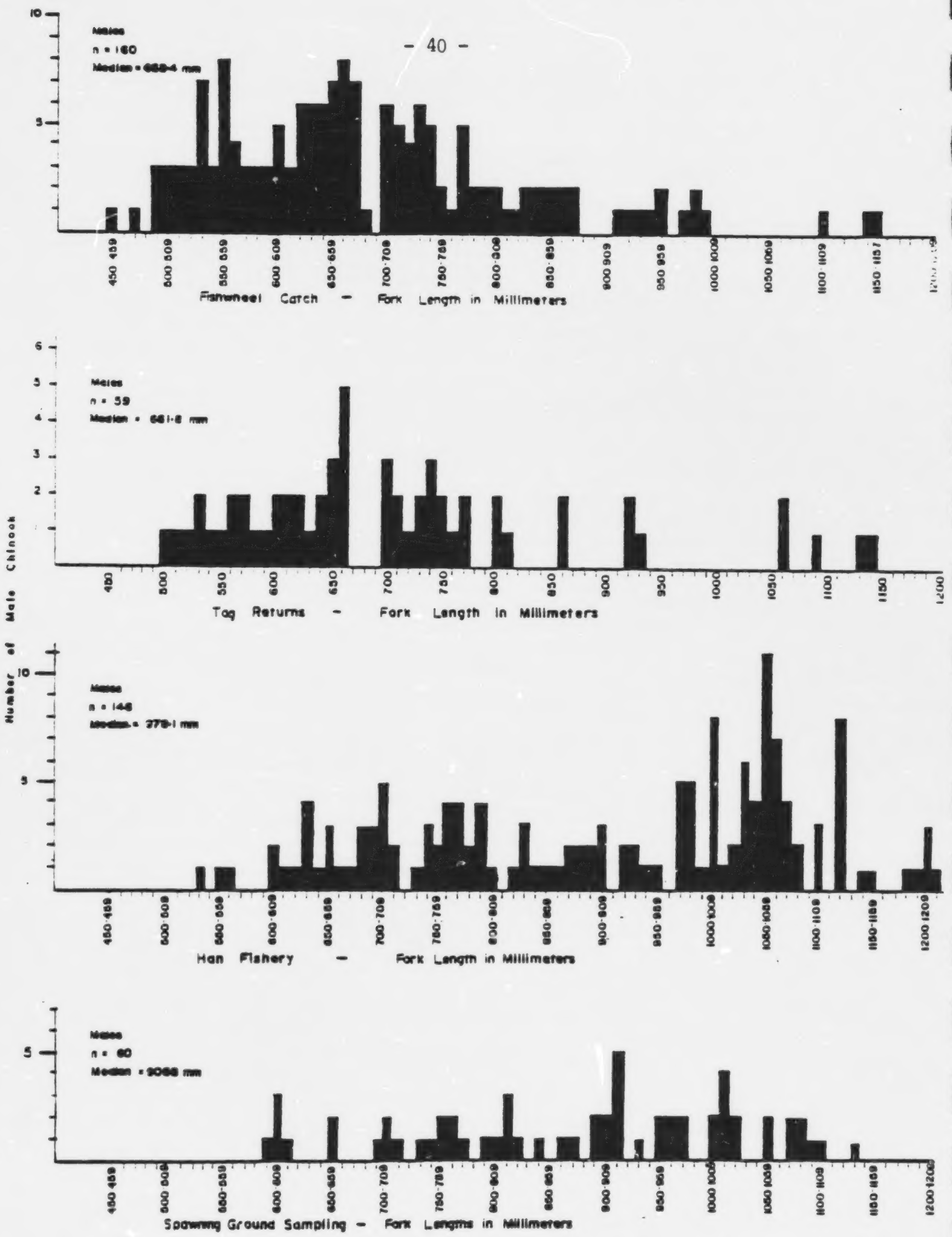

Figure 5   Length frequency of male chinook sampled in 1982.

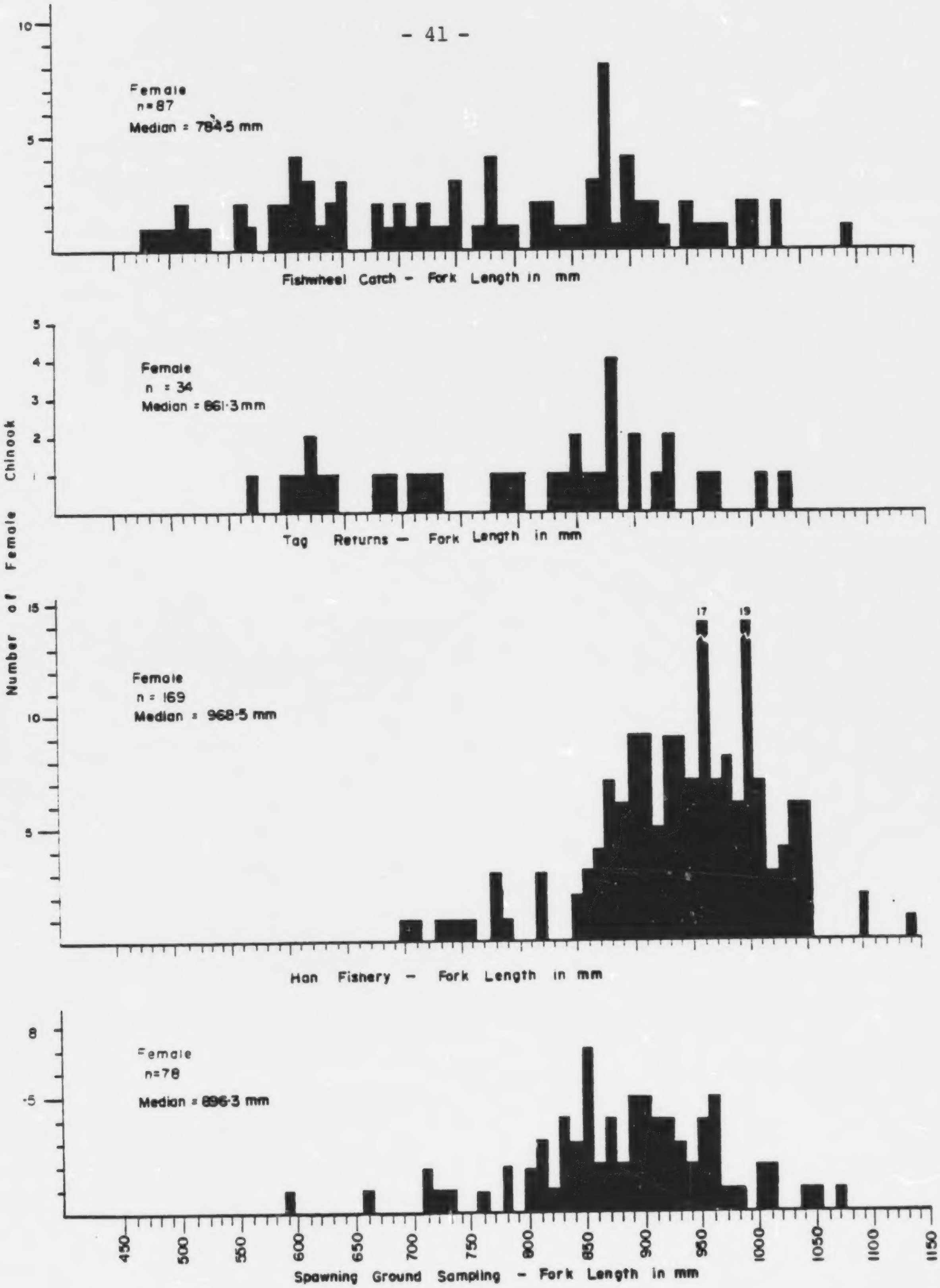

Figure 6 Length frequency of female chinook sampled in 1982.

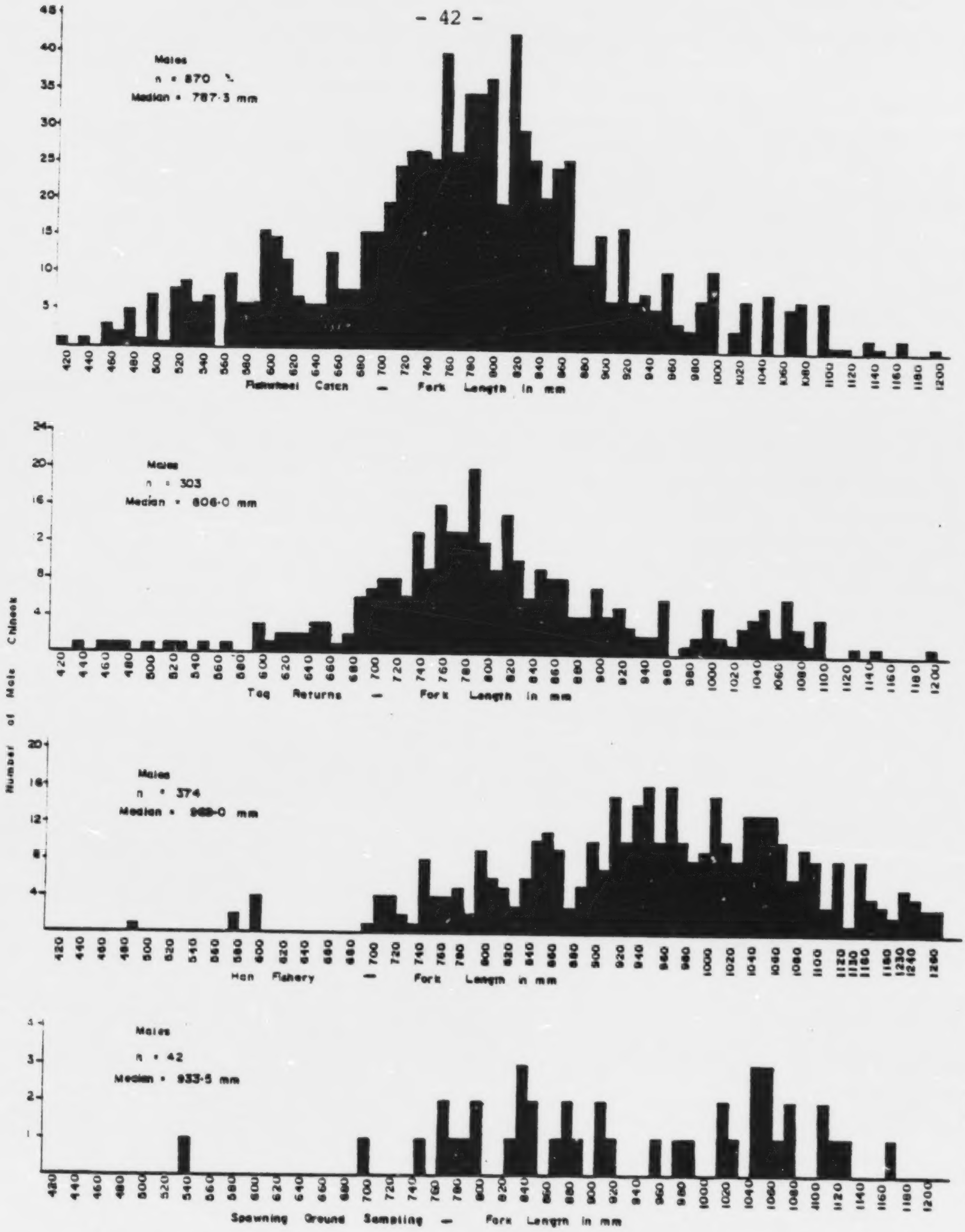

Figure 7 Length frequency of male chinook sampled in 1983.

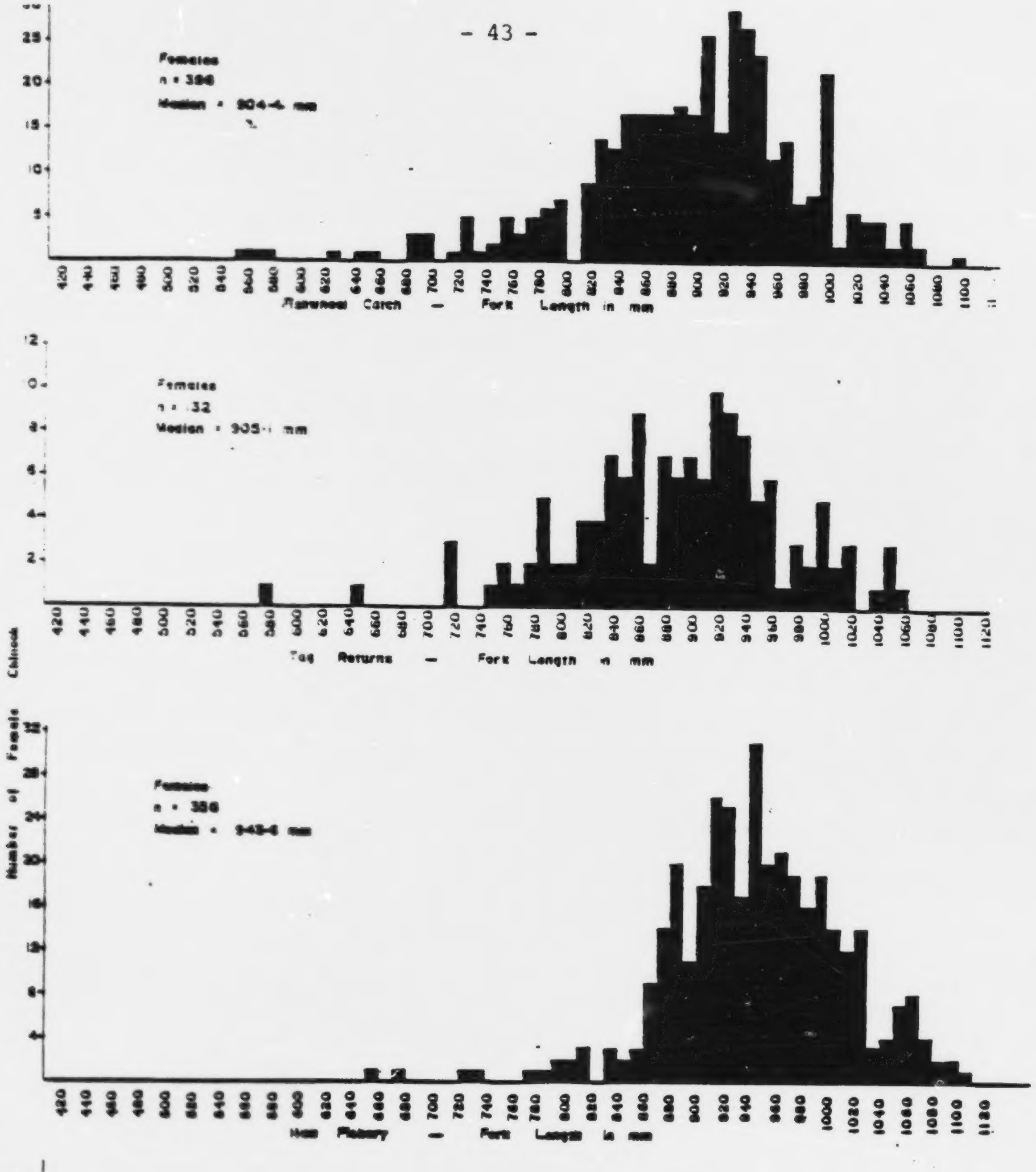

Figure 8 Length frequency of female chinook sampled in 1983.

In 1982, male chinook sampled at the Han Fishery and on the spawning grounds were approximately 200 mm larger than males sampled at the fishwheels and in the tag return sample. Female chinook sampled at the fishwheels had the shortest median fork length, and the Han Fishery sample had the largest median fork length value (968.5 mm). Normal length frequency distributions were not apparent for some sample locations in 1982 because of small sample sizes.

In 1983, male chinook at Han Fisheries had the largest median fork length value. The tag return sample had a slightly larger median fork length value than the fishwheel sample because of the fish size selectivity of the commercial fishery gillnets. For females, the Han Fisheries and spawning ground samples had the largest median fork length values.

Length-age relationships for male and female chinook sampled at the fishwheels and the Han Fishery in 1982, are presented in Figures 9 and 10, respectively. Male chinook had larger fork lengths than females, except in the 5_2 age class, although sample sizes were small. In 1983, female chinook (Figure 11) were generally larger than males (Figure 12) in the 4_2, 5_2, 6_2 and 6_3 age classes.

The largest fork length values occurred within the 7_2 age class for both sexes. In 1982 and 1983, the Han Fishery selected the largest male and female chinook in each age class (Figures 9 - 12). In general, a direct relationship exists between length and salt water age. A 6_3 chinook, with four years' salt water growth, for example, was shorter in length than a 6_2 chinook with five years of salt water growth, and even a 5_2 chinook with four years in salt water (Figures 9 - 12).

The average weight by age class of chinook sampled at the Han Fishery in 1982 and 1983 is presented in Figures 13 and 14, respectively. In both years, females were heavier than males in the 4_2 and 5_2 age classes, however, males were heavier in all other age classes. Age 7_2 males had the highest average weight (16.5 kg in 1982; 15.0 kg in 1983) (Figures 13 and 14). In general, a direct relation exists between weight and salt water residency.

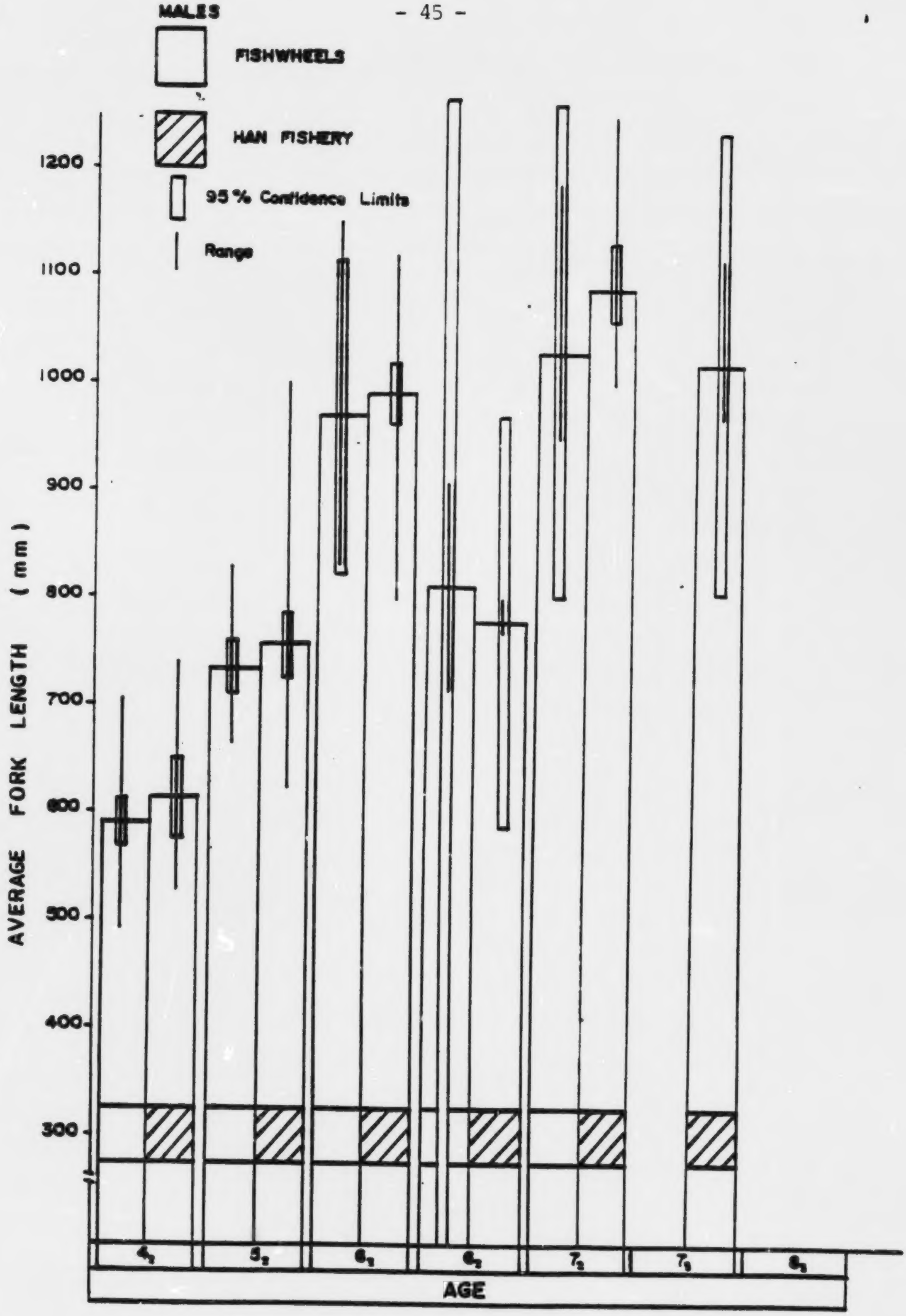

Figure 9 Length-age relationship of male chinook sampled in 1982.

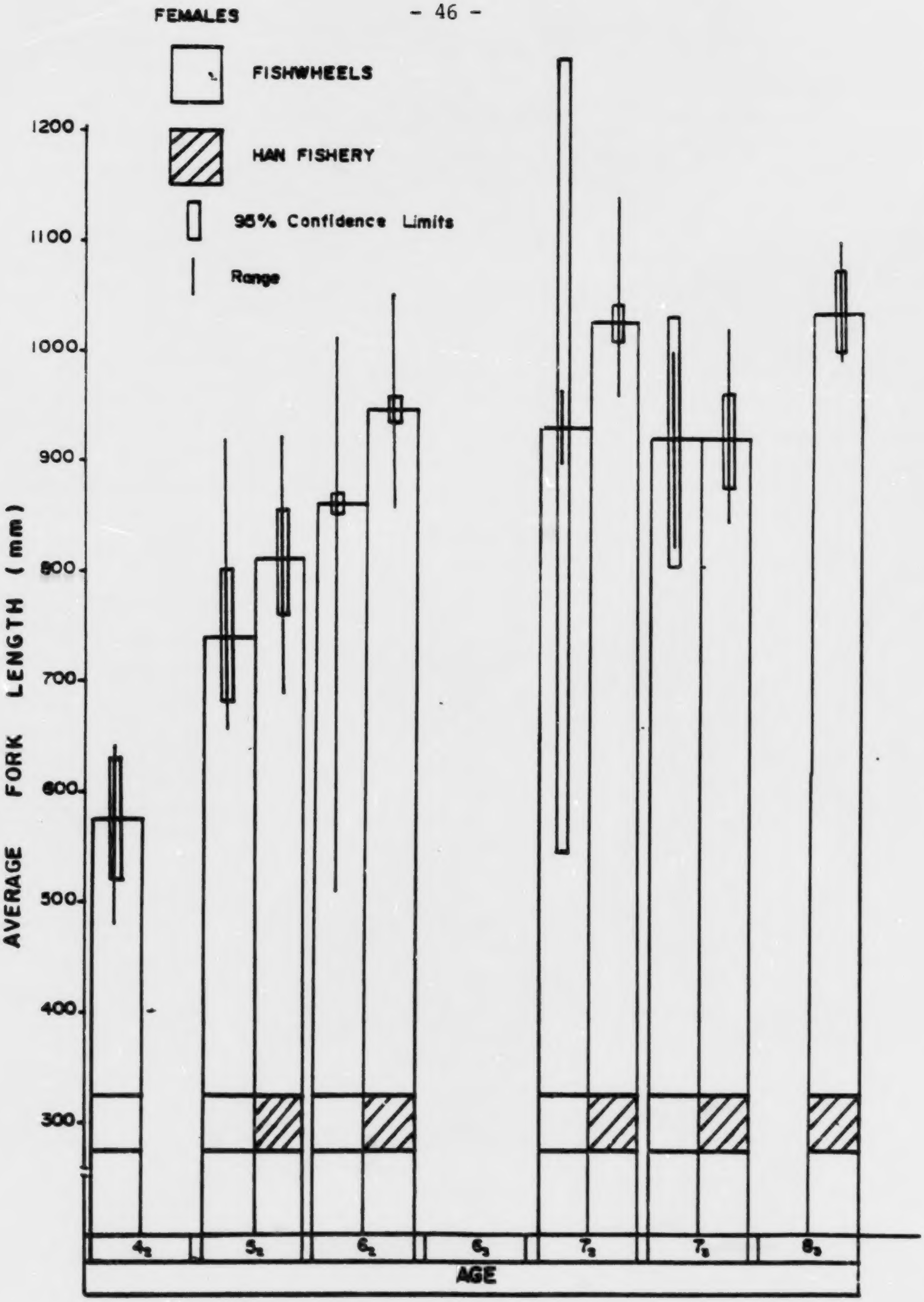

Figure 10 Length-age relationship of female chinook sampled in 1982.

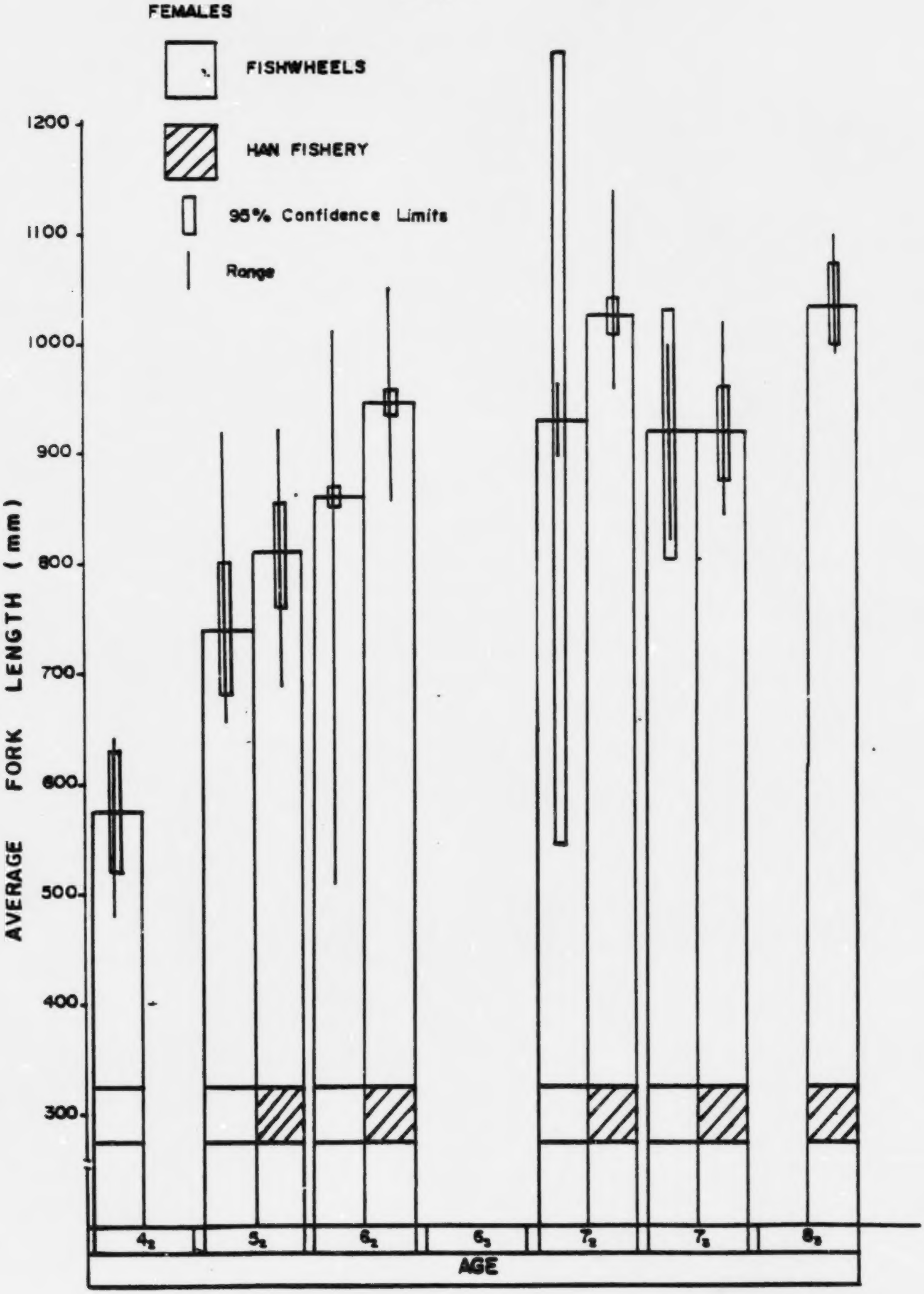

Figure 11 Length-age relationship of female chinook sampled in 1983.

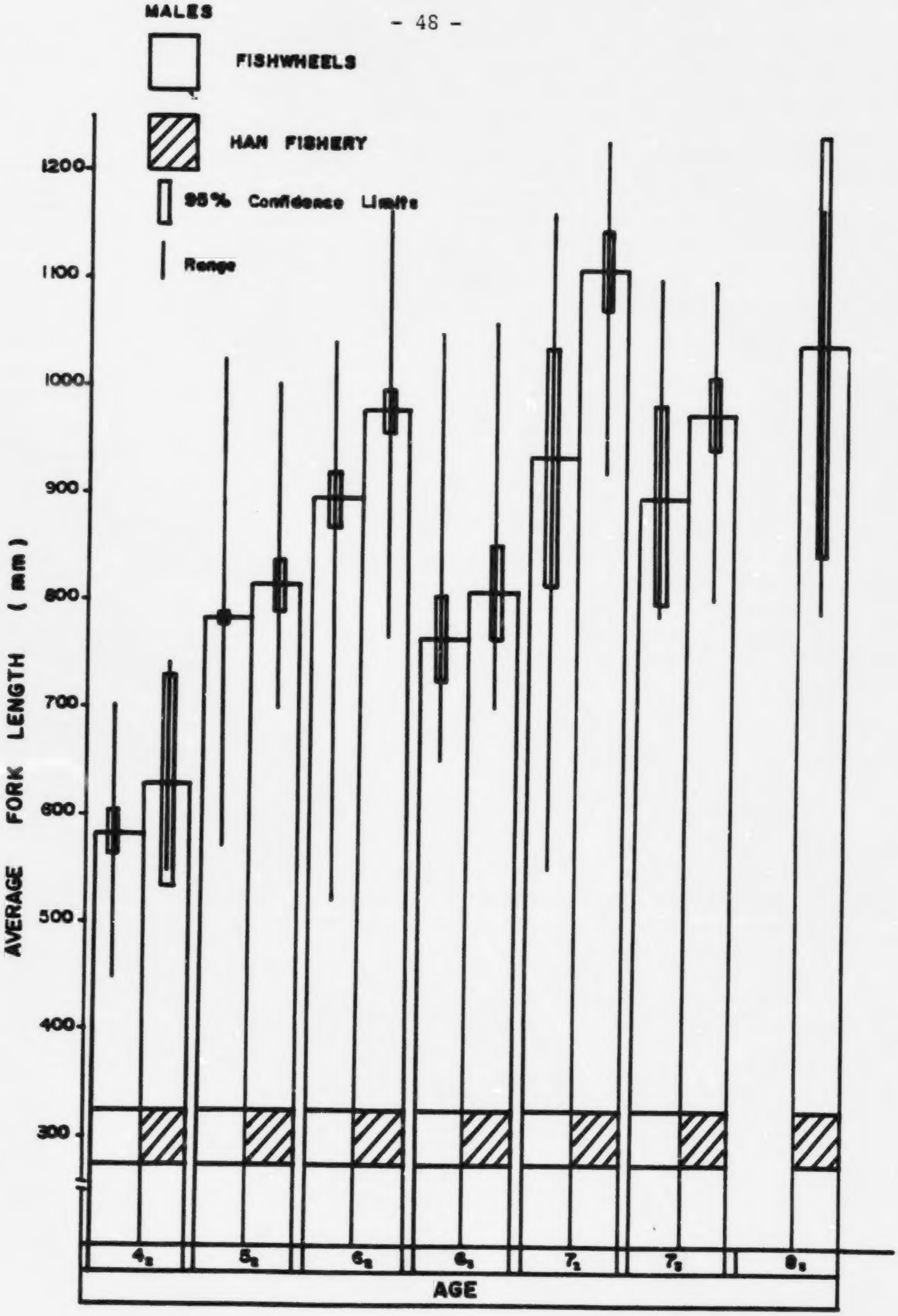

Figure 12 Length-age relationship of male chinook sampled in 1983.

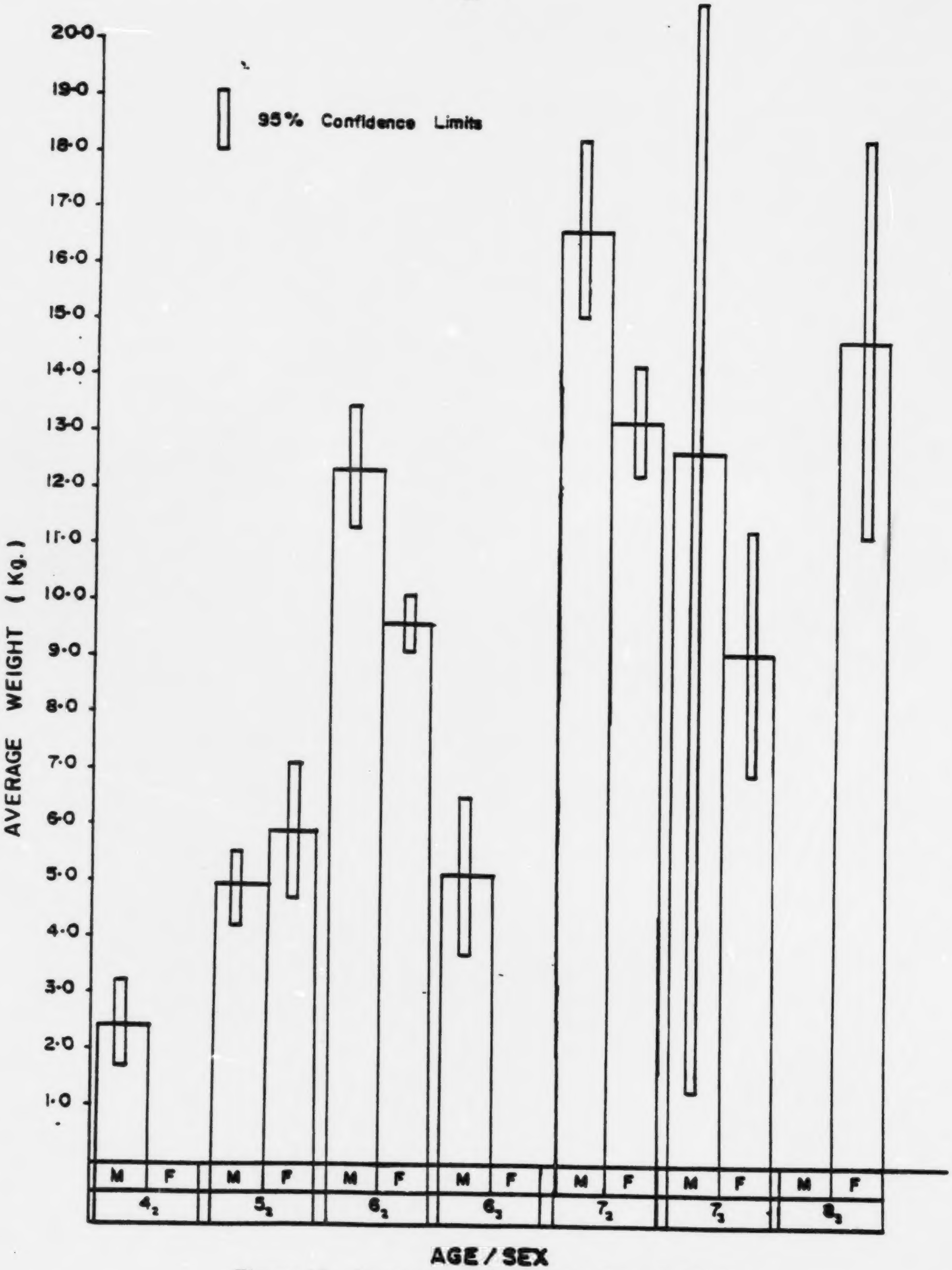

Figure 13 Average weight by age class of chinook sampled at the Han Fishery in 1982.

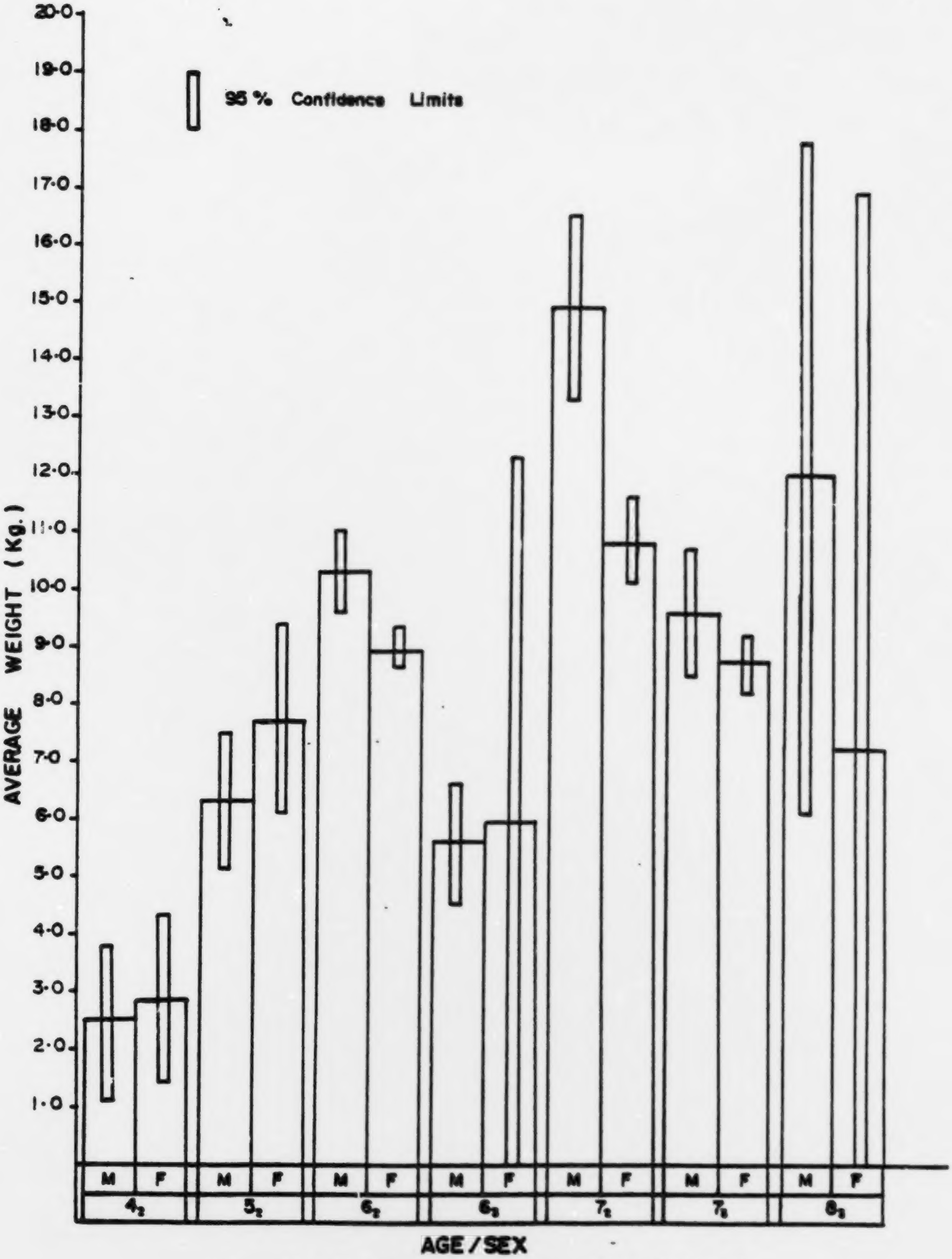

Figure 14 Average weight by age class of chinook sampled at the Han Fishery in 1983.

2.2.5.4 Other Observations

The chinook sampled were also examined for disease and deformities. White fungal growths were common among chinook on the spawning grounds. An interesting observation was a sway-back condition (kinked vertebrae column) which was evident in approximately 40 chinook in 1982 and 50 chinook in 1983.

Live-captured sway-back chinook appeared to be docile, and some had open wounds on the ventral surface of their bodies. Elson and Steigenberger (1977) attributed the sway-back condition to possible injuries suffered by smolts during downstream migration at the Whitehorse Rapids Dam, although returns of sway-back chinook through the Whitehorse fishway have not been significant. One chinook exhibiting this condition was observed in a mainstem spawning area on the Teslin River in 1982.

The results of an x-ray examination on a sway-back chinook indicated that the vertebrae column was not fractured early in the fish's life (Etherton, personnel communication). This condition, therefore, may be a type of scoleosis, or the result of other causes which could include: a genetic disorder; parasitic infestation; or possibly a temperature shock during egg development. Further investigation of this condition would be warranted if significant increases in sway-back fish occur.

Female chinook carcasses sampled in spawning areas were also examined for the presence of retained sex products. It was unusual to observe more than 10% egg retention (data were not analyzed quantitatively).

Less than 10 prespawn mortalities were observed in mainstem spawning areas and in other tributaries. The cause of death was not determined. Prespawn mortalities are of particular interest because they could be an indicator of a much larger die-off. Since the Yukon River Basin involves a very large drainage area and many spawning areas are in remote locations, a significant chinook die-off could go unnoticed.

2.2.6 Gross Escapement Estimates and Spawning Surveys

2.2.6.1 Gross Escapement Estimates

As indicated previously in section 2.1.4, gross escapement was estimated by subtracting the total catch harvested by the commercial, domestic and native food fisheries from the population estimates determined from the mark recapture programs. In 1982, the Adjusted Petersen Estimate (sexes combined) was 36,598, and the total catch was 16,408 which, by subtraction, gave an estimated gross chinook escapement of 20,190. In 1983, the population estimated by the Adjusted Petersen Estimate (sexes combined) was 47,741 while the total catch was 18,227, giving a gross escapement estimate of 29,514 chinook.

2.2.6.2 Survey of Mainstem Spawning Areas

Surveys of mainstem spawning areas were conducted from August 20 to August 22, 1982 and from August 10 to August 25, 1983. Turbidity and water depth precluded direct visual counts of chinook on redds. The following criteria were used to identify specific spawning areas:

1. the intensity of breaching activity;

2. the condition and number of spawning chinook as determined with sample gillnet drifts;

3. the presence of carcasses;

4. the presence of spent chinook;

5. the physical condition of breaching salmon (white fins, eroded tails, etc.).

Three principal mainstem spawning areas were identified in the 1982-1983 period (Figures 15, 16, and 17). Two of these areas were previously documented by Walker (1976) and the third was an undocumented mainstem area located in 1983.

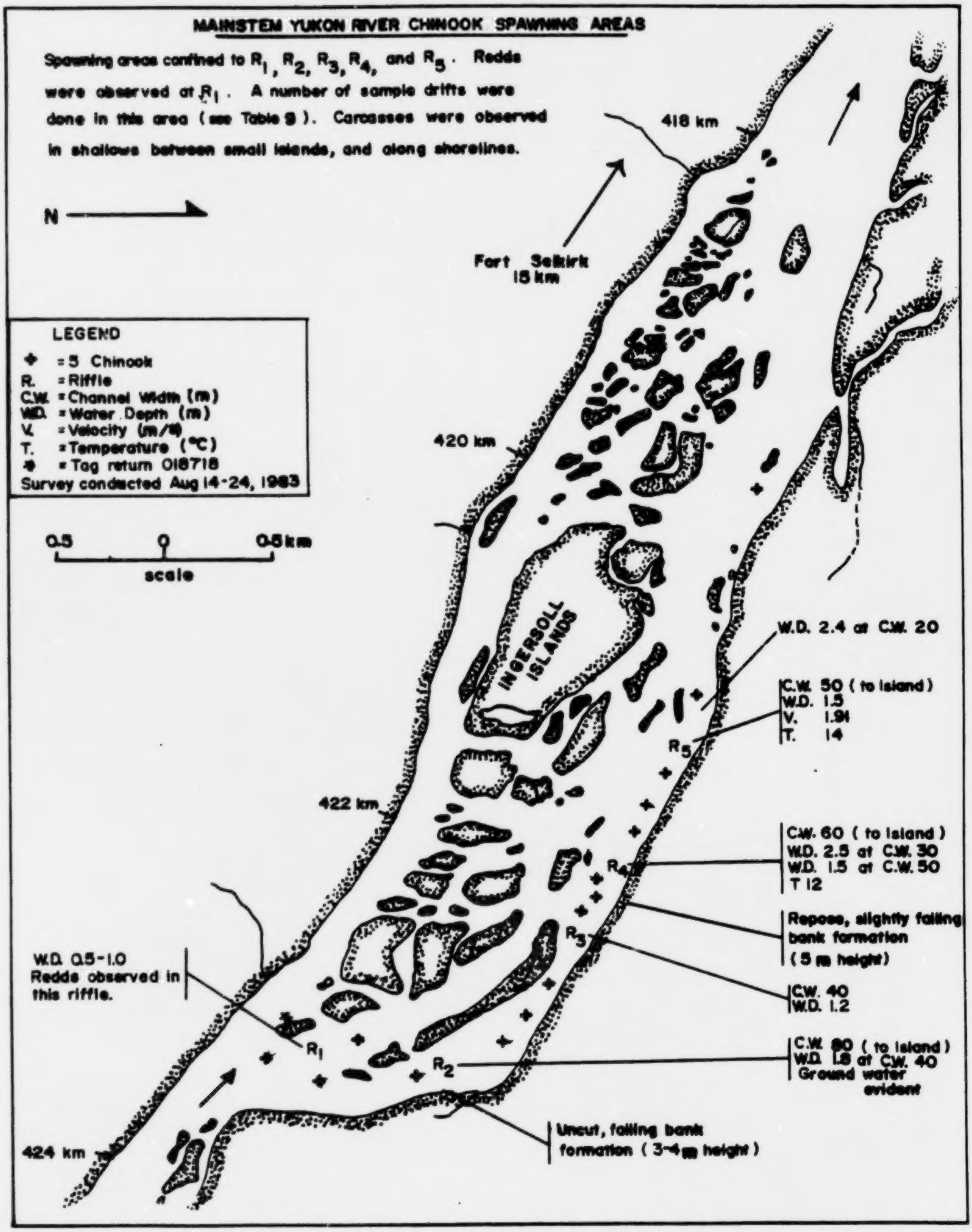
MAINSTEM YUKON RIVER CHINOOK SPAWNING AREAS
Spawning areas confined to R1, R2, R3, R4, and R5. Redds were observed at R1. A number of sample drifts were done in this area (see Table 9). Carcasses were observed in shallows between small islands, and along shorelines.
N
418 km
Fort Selkirk 15 km
LEGEND
✦ = 5 Chinook
R. = Riffle
C.W. = Channel Width (m)
W.D. = Water Depth (m)
V. = Velocity (m/s)
T. = Temperature (°C)
✦ = Tag return 018718
Survey conducted Aug 14-24, 1983
0.5 0 0.5 km
scale
420 km
INGERSOLL ISLANDS
W.D. 2.4 at C.W. 20
C.W. 50 (to island)
W.D. 1.5
V. 1.91
T. 14
R5
422 km
C.W. 60 (to island)
W.D. 2.5 at C.W. 30
W.D. 1.5 at C.W. 50
T 12
R4
Repose, slightly falling bank formation (5 m height)
R3
C.W. 40
W.D. 1.2
W.D. 0.5-1.0
Redds observed in this riffle.
R1
R2
C.W. 80 (to island)
W.D. 1.8 at C.W. 40
Ground water evident
Uncut, falling bank formation (3-4 m height)
424 km

Figure 15 Principal mainstem chinook spawning areas located in the Ingersoll Islands area. 20 km downstream of Minto.

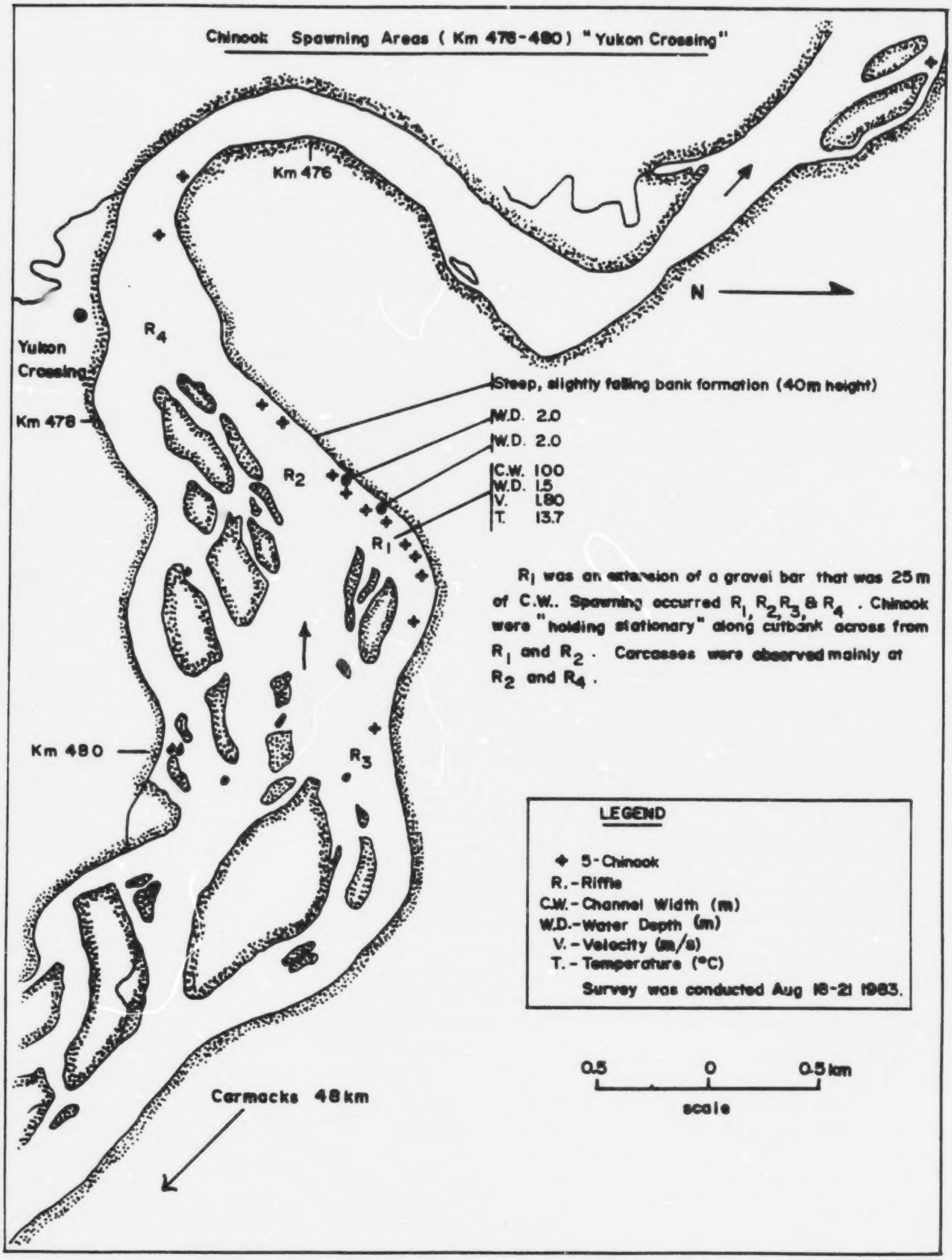
Chinook Spawning Areas (Km 476-480) "Yukon Crossing"
Km 476
N
R_4
Yukon Crossing
Km 478
Steep, slightly falling bank formation (40m height)
W.D. 2.0
W.D. 2.0
C.W. 100
W.D. 1.5
V. 1.80
T. 13.7
R_2
R_1
R_1 was an extension of a gravel bar that was 25 m of C.W.. Spawning occurred R_1, R_2, R_3, & R_4 . Chinook were "holding stationary" along cutbank across from R_1 and R_2 . Carcasses were observed mainly at R_2 and R_4 .
Km 480
R_3
LEGEND
✦ 5-Chinook
R. - Riffle
C.W. - Channel Width (m)
W.D. - Water Depth (m)
V. - Velocity (m/s)
T. - Temperature (°C)
Survey was conducted Aug 18-21 1983.
0.5
0
0.5 km
scale
Carmacks 48 km

Figure 16 Mainstem Yukon chinook spawning areas located at Yukon Crossing, 12 km downstream of the Yukon-Tatchun Creek confluence.

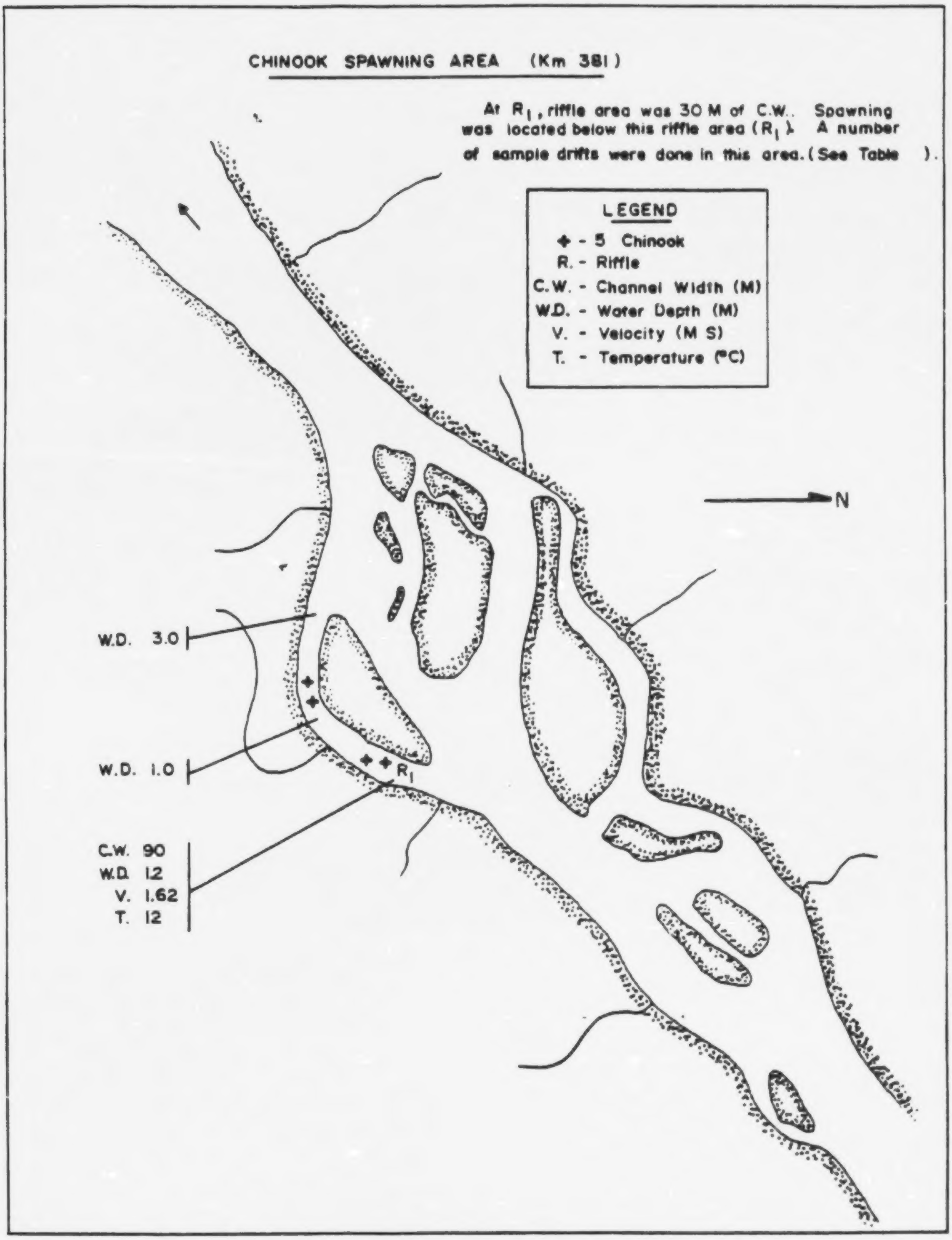
CHINOOK SPAWNING AREA (Km 381)
At R1, riffle area was 30 M of C.W.. Spawning was located below this riffle area (R1). A number of sample drifts were done in this area. (See Table).
LEGEND
✦ - 5 Chinook
R. - Riffle
C.W. - Channel Width (M)
W.D. - Water Depth (M)
V. - Velocity (M S)
T. - Temperature (°C)
N
W.D. 3.0
W.D. 1.0
R1
C.W. 90
W.D. 1.2
V. 1.62
T. 12

Figure 17 Mainstem Yukon chinook spawning area at km 381 (23 km below Fort Selkirk).

The most important spawning area was located in the vicinity of the Ingersoll Islands between reference points km 418 and km 424 (Figure 15), where 78 chinook were observed in 1983 (Table 8). Spawning sites were associated with five riffle areas located at the north bank where active gravel recruitment was evident. Spawning was evident from breaching activity observed at the riffle areas, the capture of 16 chinook in drift gillnets (Table 9), and the sighting of 11 carcasses. Two of the carcasses, both females, were prespawn mortalities, although peak die-off occurred after the survey period August 14 to 22, 1983.

The second most important spawning area was located at Yukon Crossing (km 475 - 480) (Figure 16), where in 1983, 64 live chinook were observed spawning at four riffle areas. Most of the spawning activity occurred at a site identified as R_1 (Figure 16), where active gravel recruitment from a steep bank was evident. Three chinook were gillnetted and three carcasses were observed (Tables 8 and 9).

An undocumented spawning area was located in a side channel at km 381 (Figure 17), 23 km below Fort Selkirk. A riffle area covered approximately one-third of the channel width, and water depth varied from 1.0 to 1.2 meters. Three chinook were gillnetted and four carcasses were examined. Peak die-off had not occurred by August 20, 1983 when the survey was conducted.

The mainstem Yukon River spawning areas appeared to be the major producers of chinook salmon, although the magnitude of chinook production in these areas is difficult to determine.

2.2.6.3 Surveys of Other Spawning Areas

Aerial and ground surveys of a selected number of spawning areas were conducted, and the chinook escapement into the upper Yukon drainage above Whitehorse was monitored at the Whitehorse Fishway. The results of ground surveys are presented in Appendix 5, and the aerial survey results are presented in Appendix 6. As indicated previously in section 2.1.4, the 1983 aerial surveys were conducted in conjunction with final radio tracking flights and they may not correspond with the peak spawning period.

Table 8 Chinook spawning ground surveys along the mainstem Yukon River from below Fort Selkirk to Tatchun Creek: 1982-1983

	1975		1982**	1983***		
Km	Live[1]	Dead	Live[2]	Live[2]	Dead	Tag Recovered
370-375				0	0	
375-380				0	0	
380-385				20	4*	
385-390				0	0	
390-395				0	0	
395-400				0	0	
400-405	0	0		0	0	
405-410	0	2		0	0	
410-415	0	0		0	0	
415-420	11	15	29	2	3	
420-425	36	16		67	11*	18718
425-430	2	10		11	0	
430-435	1	2		17	2	
435-440	0	1		0	0	
440-445	1	1		0	0	
445-450	7	6		1	1	
450-455	0	2		0	1	16311
455-460	1	5		1	0	
460-465	2	0		0	0	
465-470	2	4		4	0	
470-475	4	22		3	1	
475-480	3	7	21	62	2	
480-485	2	5		0	0	
485-490	0	0		0	0	
490-495	0	0		19	0	
	72	98	50	207	25	2

1 Visual sighting August 28, 1975 and later; extracted from Walker (1976)
2 Visual sighting "Rollers"
* Includes prespawn mortalities (total of 4)
** Limited survey conducted (Ingersoll Islands and Yukon Crossing) August 20-22, 1982
*** Survey conducted between August 10 and August 25, 1983, and counts do not include drift net results

Table 9 Results of drift netting conducted in spawning grounds on the mainstem Yukon River.

Location (km)	Number of Chinook Netted	Sex		Condition	Date
		Male	Female		
381	2	2		both spewing milt	20/08/83
381	1		1	spawned out	20/08/83
421	1	1		partially spawned, over 30 lb	18/08/83
421	1		1	spawned out	18/08/83
422	8	7**	1	most males partially spawned, over 30 lb	18/08/83
423	3	3		1 male spawned out	19/08/83
423	3	2	1	white tails on males	19/08/83
480*	1	1		spewing milt	18/08/83

* several other drifts were made; however, current velocity made netting difficult

** includes two jacks (not spawned)

Aerial surveys of a number of Canadian index streams were conducted by the Alaska Department of Fish and Game. The results of Alaskan surveys conducted from 1980 to 1983 are presented in Appendix 3.

Available survey information suggested that chinook escapement was below average to poor in both 1982 and 1983, when escapements to index areas were lower than 1980 and 1981 escapements. A strong chinook return occurred in 1980 while the 1981 return was the highest recorded.

Chinook escapement through the Whitehorse Fishway totalled 473 in 1982 and 905 in 1983 (Appendix 7), however, the Whitehorse Fishway may not be a good indicator of overall chinook escapement, because of possible smolt mortality during downstream migration.

2.2.7 Migration Rates and Timing

The average chinook migration rates from the tagging site to recapture locations below the Stewart-Yukon confluence were 33.0 ($n = 68$) and 24.6 ($n = 173$) km.day^{-1} in 1982 and 1983, respectively. The lower migration rate in 1983 appeared to have resulted from the high water conditions which persisted throughout the 1983 chinook run. The average migration rate of chinook recaptured in tributaries or upriver locations in 1983 was 36.3 km.day^{-1} ($n = 79$).

In 1982, the first chinook was tagged on July 13. The 1982 run occurred approximately two weeks later than runs in the previous two years. The last chinook was tagged on August 30. Peak chinook migration occurred during the week of July 28 to August 2 (Figure 18). The chinook migration in the Dawson area ended on approximately September 5. Few chinook were caught in the commercial fishery in the two week period preceding this date. In 1983, the first and last chinook were tagged on July 1 and September 12, respectively. Peak migration occurred between July 26 and August 1 (Figure 19).

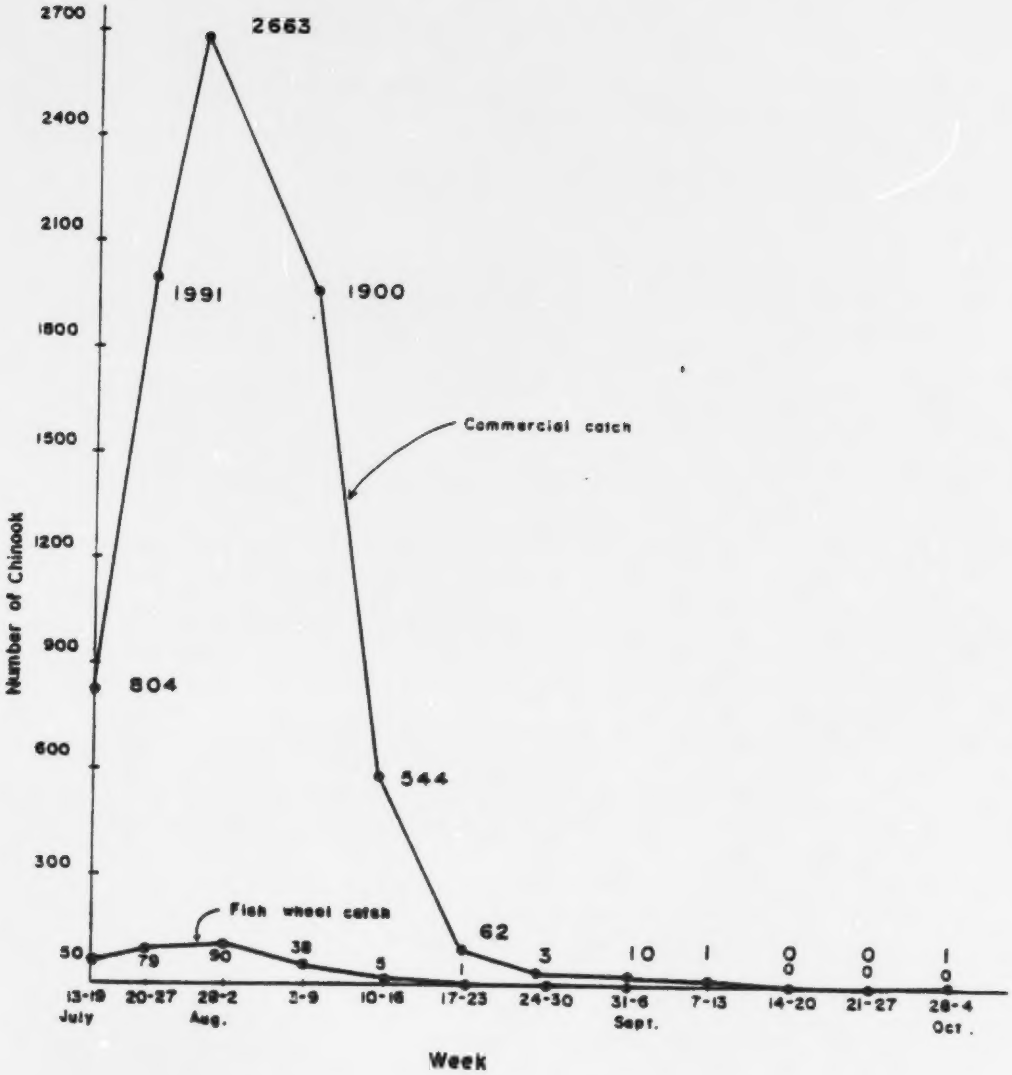

Figure 18 Fishwheel and commercial (Dawson area) chinook catches, 1982.

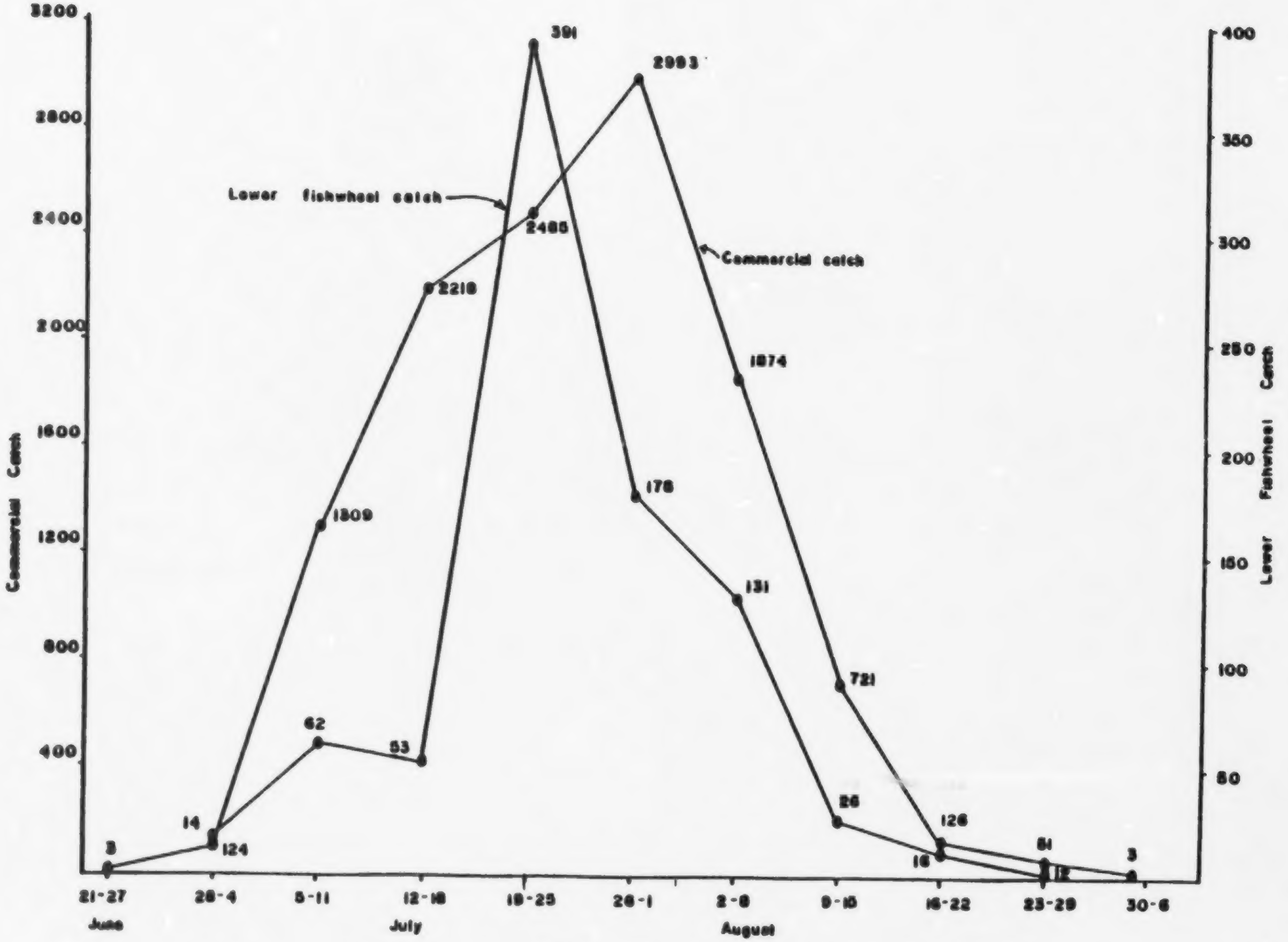

Figure 19 Migration timing and relative abundance of chinook salmon in the Dawson area, 1983.

These calculated migration rates and the observed timing are important with respect to the management of closure periods, because they determine the length of time migrating chinook stocks are subject to fishing activity. The commercial fishery is primarily distributed along a 100 km section of the mainstem Yukon between Dawson City and Cliff Creek. Cliff Creek is located approximately 50 km upstream of the international boundary. Based on the migration rates calculated in 1982 and 1983, chinook migrating through this area were subjected to three to four days of fishing pressure. The one to two day closure periods that were in effect throughout the 1982 and 1983 seasons were not of sufficient length to permit chinook stocks to avoid fishing pressure. Even a closure period of four days per week would allow only a one day segment of the chinook run to migrate unfished through the Dawson area (based on migration rate of 33 $km.day^{-1}$, and therefore a three day period for the fish to pass through the area). The one to two day closure period used during the 1982 and 1983 seasons may not be long enough to permit adequate escapement. A more effective means of obtaining adequate escapement levels would involve a variable open period strategy with a minimum closure period of four days per week during periods of peak chinook migration.

3.0 CHINOOK RADIO-TAGGING PROGRAM 1983

3.1 Materials and Methods

3.1.1 Capture Techniques and Transmitter Implantation

Adult chinook salmon were live-captured by fishwheels located 12, 15, 89 and 142 km above the Yukon/Alaska border (Figure 1). Chinook were scooped up by the fishwheel baskets and deposited into live-boxes (section 2.1.1.1), or in the case of the commercial fishwheel located at km 142, into fish totes filled with water.

Transmitter implantation required two people. The chinook deposited in the fishwheel live-boxes were removed with a fine mesh dip net and placed in a fish tote (1.0 m x .5 m x .5 m) filled with water (Plate 3). One person held the fish by the caudal peduncle with one hand and cradled its body with the other while keeping its head submerged in the water. A radio transmitter was inserted by a second person using a glass pipette as an insertion rod. The antenna of the radio tag was passed through the pipette until approximately 3 cm of the antenna wire protruded through the end. Glycerine was then liberally applied to the tag as a lubricant (Plate 4), and the antenna wire and the glass pipette were used to position the tag. The radio-tagger held the lower jaw of the fish, opened its mouth, and placed the tag against the back of the fish's throat. The tag was inserted in the lower esophagus or anterior gut by applying gentle pressure. During tag insertion, it was beneficial to release the lower jaw as the fish would then open and close its mouth (swallow) and this would ease the entry of the tag. The whip antenna usually protruded to the end of, or 2 to 3 cm beyond the fish's snout and was not fixed in any way (Plate 5 and 6). Fish were released immediately after tag insertion, which took 30 to 45 seconds to complete. Removal of fish from the water occurred only during the transfers from the live-box to the fish tote and from the fish tote to release in the river (Plate 7).

Plate 3 Large chinook in fish tote. Ends of spaghetti tags are being knotted together. Note the silver bright condition of this fish.

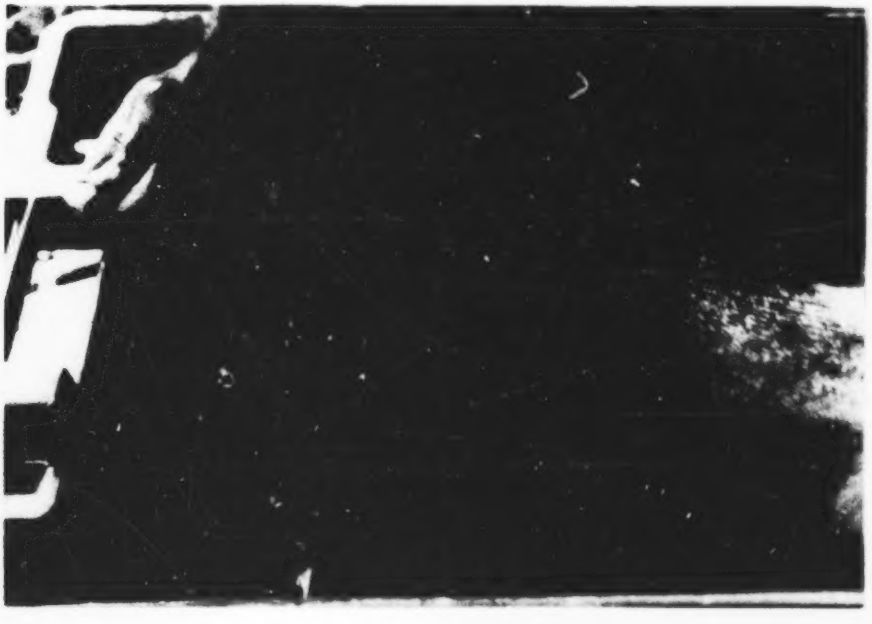

Plate 4 The glycerine-coated (lubricant) transmitter was inserted with the aid of a pipette into the lower esophagus or anterior of the stomach.

Plate 5 The transmitter was not fixed in any way and the whip antenna usually protruded 2-3 cm beyond the fish's snout.

Plate 6 Final positioning of a radio transmitter. Tag insertion took from 30-45 seconds to complete.

Plate 7 Release of a chinook after radio tag implantation. Note the advanced stage of maturity of this female chinook.

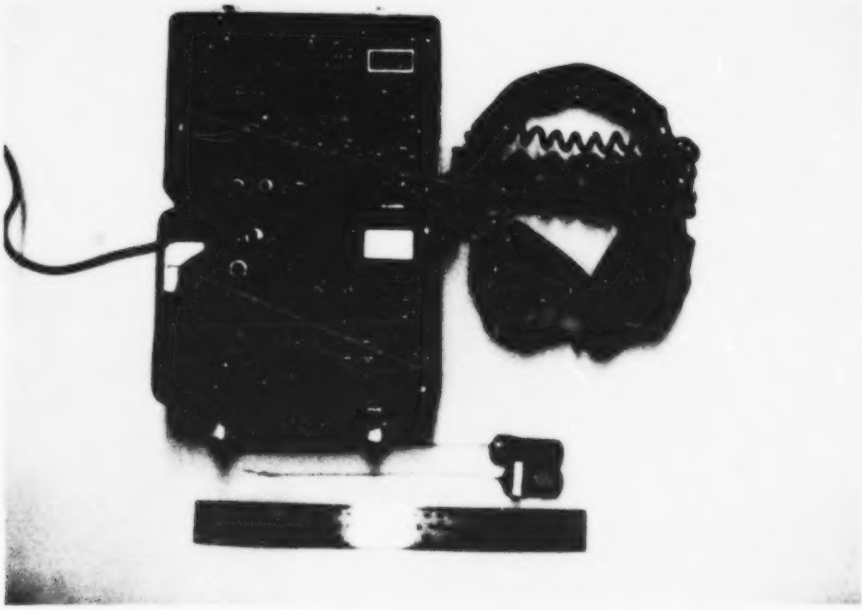

Plate 8 Telemetry Equipment: Falcon Five receiver and APS-164 scanner in photo were operating on the frequency (151.586 megahertz) of the large transmitter. Small transmitter is in off position (note magnet).

Departures from this tagging technique were as follows:

1. oxygen from a standard oxygen (O_2) bottle was bubbled into the fish tote while tag insertion took place and the fish was held for five to ten minutes before being released;

2. some radio-tagged chinook were tagged in the evening, held in the live-box overnight, and released the following morning.

Transmitter placement was examined a number of times at the different tagging sites to ensure that the transmitters were properly seated in the gut. The examinations involved transmitter insertions into live and dead chinook followed by necropsies. Chinook recaptured in the various fisheries were also examined to check the integrity of the gut lining.

3.1.2 Radio Telemetry Equipment

The radio telemetry equipment used in this study was manufactured by Wildlife Materials, Inc., Carbondale, Illinois (Plate 8). The radio transmitters were individually identifiable and operated on frequencies in a 1,000 kilohertz band between 150.800 and 151.800 megahertz. The separation between each frequency was approximately 20 kilohertz. Each transmitter was a self-contained, hermetically sealed unit with an outer shell consisting of dental acrylic and an external whip antenna 20 mm in length. All transmitters were two-stage, miniature units which emitted pulsing signals at rates set at 45-50, 60-75, 96-120 or 150-200 pulses per minute. Four pulse rates were used in conjunction with 50 frequencies, thus giving a total capacity of 200 individually identifiable transmitters. Transmitter dimensions, weight, and life expectancy were variable depending on the pulse rate, pulse width, and the size of the lithium battery used. Transmitter dimensions were 45-55 mm (length) x 20-23 mm (width) x 20-22 mm (maximum diameter) (Figure 20). Dry weight ranged from 16 to 26 grams. Transmitter life expectancy was 50 to 90 days. The transmitters were activated by the removal of a small, external magnet which operated as the on/off switch (Plate 4).

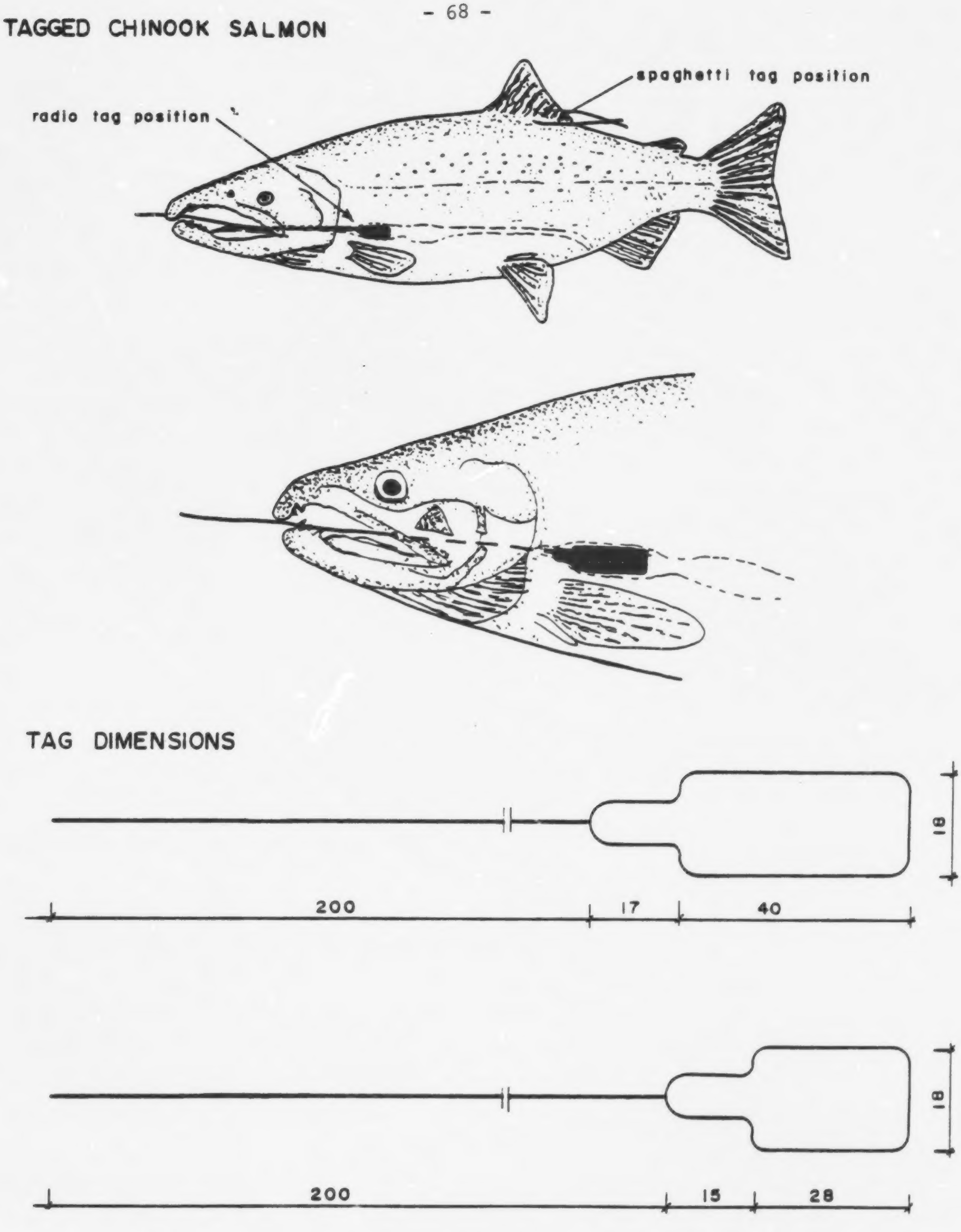
TAGGED CHINOOK SALMON
spaghetti tag position
radio tag position
TAG DIMENSIONS
18
200
17
40
18
200
15
28

Figure 20 Radio transmitter placement in anterior stomach. Actual transmitter dimensions are shown in bottom figures. All measurements are in millimeters.

Transmitter range, which averaged approximately 0.8 km on the ground and 1.6 km from the air, varied with the depth of the fish in the water, and with the transmitter orientation to receiving antennae. The effective transmitter range was reduced considerably under certain conditions (see section 3.2.1).

Two types of radio receivers were used. The radio receivers operated on a 1,000-1,200 kilohertz band of reception which complemented the transmission range of the transmitters. One type was a programmable Falcon Five receiver (1,000 kilohertz rang , with an APS-164 lid-mounted scanner. This unit was equipped with a memory capacity of 64 individual channels and variable scan rates from 5 to 40 seconds/channel. A rapid activation-deactivation system permitted selecting and scanning of a number of discrete frequencies at any given time. The second type of receiver was a TRX-24, which operated over a 1,200 kilohertz range with a 48 channel capacity. Each channel covered approximately 25 kilohertz with a 5 kilohertz overlap between channels.

Stationary receiving units positioned on hillsides overlooking streams were used to monitor the dispersal of radio-tagged chinook into tributaries. Each stationary unit consisted of a three-element Yagi antenna and a Falcon Five receiver with an attached APS-164 lid-mounted scanner, which was connected to a command print Model 288 Rustrack recorder (Gulton Industries, Rhode Island) via an ERC-16 interface module (Wildlife Materials Inc.). The Rustrack print recorder indicated the presence or absence of as many as 16 discrete frequencies on time calibrated strip chart paper. Power was provided by a 12 volt automobile battery.

Three types of antenna arrays were used for aerial tracking. The first two arrays consisted of matching pairs of omni-directional citizen's band (CB) antennae. A pair of self-grounding 1/2 wavelength antennae (one meter in length) was mounted with brackets and hose clamps to the front wing struts of the aircraft (facing downward). A full wavelength pair (two meters in length) was mounted vertically and grounded to a telescopic bar that spanned between the metal steps of the aircraft (Figure 21). Each full wavelength antenna was located a

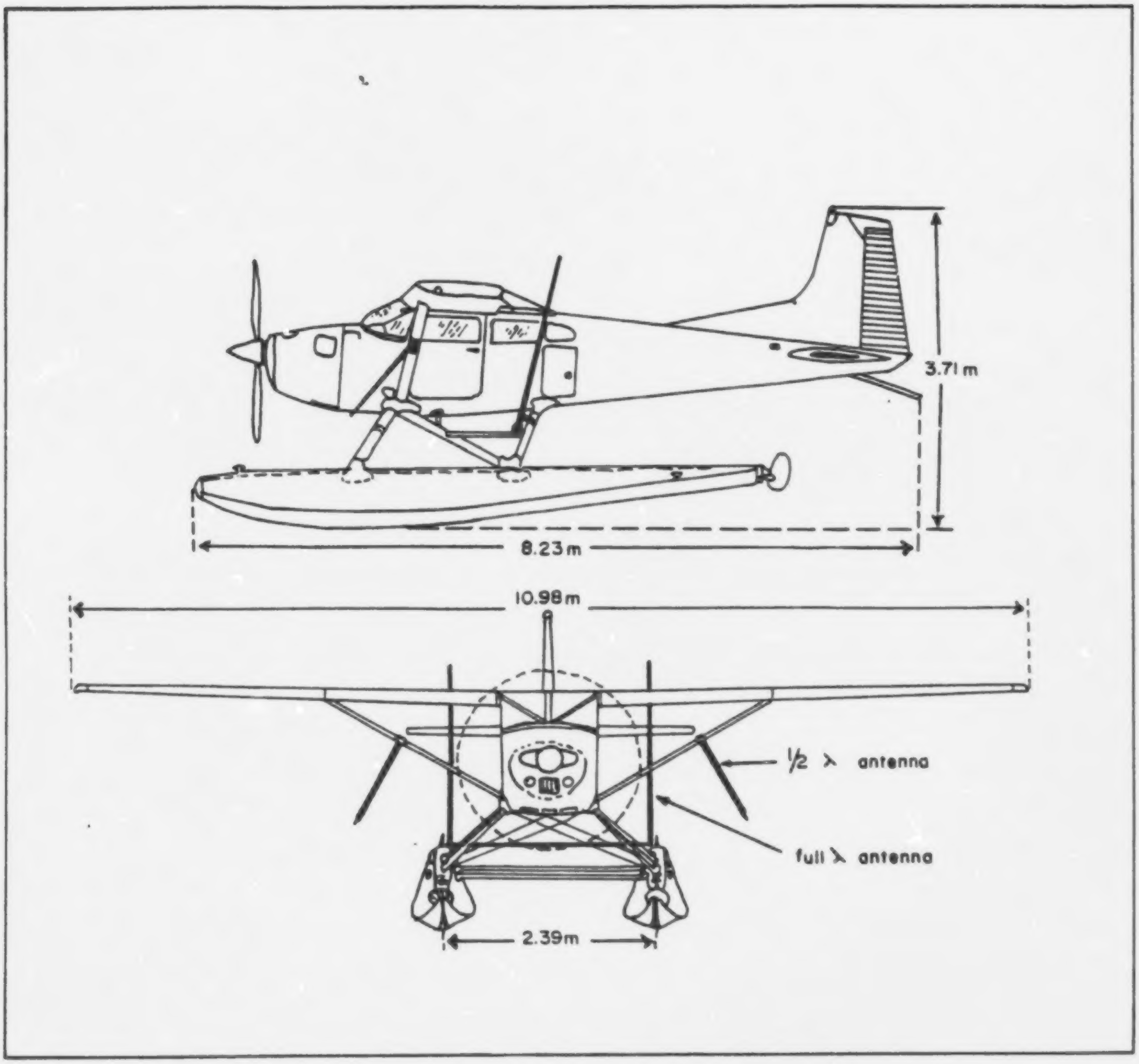
3.71 m
8.23 m
10.98 m
1/2 λ antenna
full λ antenna
2.39 m

Figure 21 Cessna 185 floatplane with 1/2 wavelength antennae (1 meter) attached to front wing struts and full wavelength antennae (2 meters) positioned behind wings.

distance of 1/2 wavelength from the fuselage of the aircraft. The third antenna array consisted of a pair of three-element Yagi directional antennae, which was used to replace the strut mounted 1/2 wavelength CB antenna which lacked gain when the radio signals were weak. The Yagi antennae were mounted in opposite directions. One antenna faced the direction the plane was travelling and the other faced behind the aircraft. All antennae arrays were connected by RG-58/U co-axial cophase cable which was passed through inspection ports located on the underside of the fuselage. Independent antenna leads were available inside the aircraft.

3.1.3 Tracking Techniques

The initial tracking near the tagging site was conducted by boat or on foot. Emphasis was placed on determining the fish's initial movements and immediate response to tag implantation. Observers used manual and/or programmable receivers with hand-held three-element Yagi antennae.

Aerial tracking surveys were conducted daily with a Cessna 185 floatplane, flown at airspeeds between 150 and 185 $km.h^{-1}$ and at an altitude of approximately 305 meters. In areas where the signals were strong, the altitude was increased to 915 meters. As the fish dispersed from the tagging sites, surveys were designed to maximize the coverage of the fish closest to the tagging site. The tracking of each fish occurred daily during its migration in the mainstem Yukon, and was discontinued after it entered a tributary.

The aerial surveys usually required two observers, who used independent scanner-receiver, antenna array, and headphone sets to scan a maximum of five to nine frequencies at any time during aerial tracking surveys. Several factors limited the number of frequencies scanned, including the speed of the aircraft, signal strength and the amount of time required to complete a scanning sequence. Distances from the respective tagging sites were marked on 1:250,000 scale maps in 2 km increments, the location (to the nearest kilometer) of each fish observed, and the time of the observation, were recorded. An hourly migration rate was calculated for each fish with the following formula:

$$\text{Hourly migration rate} = \frac{\text{distance travelled between observations (km)}}{\text{number of hours elapsed (h)}}$$

The calculated migration rates were then used to predict the location of the fish during subsequent surveys.

3.1.4 Biological Sampling

Biological sampling was conducted while tag implantation took place. Sex was determined by visual examination of body shape and/or secondary sexual charateristics. Scale samples were obtained as described previously in section 2.1.5. Fork length was determined to the nearest millimeter with a 1,000 mm hypural stick mounted to the tagging box (fish tote). Because the collecting of biological information was of secondary importance to the main goals of rapid transmitter placement and immediate release of the fish, scale samples were not always taken.

3.1.5 Spawning Ground Surveys

Spawning surveys were conducted in conjunction with aerial tracking surveys. Visual counts of spawning salmon were made at altitudes of approximately 60 to 90 meters and an airspeed of approximately 148 km.h^{-1}. Two observers were used during these surveys with one person observing from each side of the aircraft.

3.1.6 Water Flow Data

River discharges were obtained from recording stations operated by Water Survey of Canada. Two sets of discharge data for the Yukon River were obtained, one from a station at Dawson City and one from a station above the White River. Stewart River discharge data were obtained from a station located near the Stewart-Yukon confluence.

3.2 Results and Discussion

3.2.1 Transmitter Application

One hundred and thirty radio transmitters were applied to chinook salmon live-captured by fishwheels located 12 to 142 km above the international boundary on the Yukon River. A schedule of tag applications by location is presented in Appendix 7.

As the tagging program progressed, the behaviour of the radio-tagged chinook revealed limitations in the program design and in the capabilities of the radio telemetry equipment used. A number of the tagged chinook exhibited migratory delay or downstream movements that complicated tracking surveys. This behaviour was attributed to stress from environmental conditions, including high water and high suspended solids levels, the effects of confinement and transmitter application, and possible behavioural responses specific to chinook salmon. These problems were not encountered to the same degree in a similar Yukon River radio-tagging program involving chum salmon (Milligan et al. 1984). Radio-tagged chinook also were more vulnerable to recapture in the commercial fishery than was anticipated, probably because of the same stress factors.

The principal tagging site (Cassiar Creek) was chosen primarily because it was a proven fishing location. An additional upriver tagging site was planned, however, a lack of field personnel prevented the establishment of this site in 1983. Radio and spaghetti tags could be applied at the Cassiar Creek site, and recaptured radio-tags could be retrieved and reapplied. A recapture rate of less than 20% was expected of this site. The results of the 1982 program indicated that capturing chinook could be a problem. As the program progressed, it became apparent that live-capturing chinook was not a problem in 1983. The major problems, as outlined previously, were the erratic post-tagging behaviour and the vulnerability of the tagged fish to recapture. A possible solution to the problem of higher than expected recaptures would have been to move the tagging site further from the fisheries, but this would have required additional personnel, who were not available until later (mid-July). Another possible solution involved the application of a large number of transmitters in an attempt to offset recaptures, but the number of transmitters applied was limited by the ability of radio trackers to track the fish, and the effective number of transmitters was lower than originally planned.

The limitations of the radio telemetry equipment became evident when tagged fish increased the depth at which they migrated or when clear weather conditions prevailed. Radio signals were occasionally undetectable or so faint that only a well experienced radio-tracker could detect them. Aerial signal range was 2 to 3 km during optimum conditions. Signal-related problems occurred primarily in the mainstem Yukon River below the confluence with the White River. Signal strength usually increased when fish entered tributaries or migrated above the Yukon-White confluence. Faint signals or complete signal loss were attributed primarily to the attenuation of radio waves which increased as the fish moved deeper in the water. Conductivity did not appear to be a limiting factor in signal transmission range, although it was not measured in this study. The first observations of reduced or undetectable signals occurred on July 12 following a significant drop in the water level of the river. Chinook migrated at greater water depths during reduced flow periods. Radio signals that were undetectable below the White River were constantly scanned for in upriver locations. Observers relocated a number of the lost signals in this manner, and the fish were then successfully tracked from that point on.

3.2.2 Distribution of Tagged Fish

Radio-tagged chinook were tracked into all sub-basins within the study area (Figure 22). A summary of the distribution of the tagged chinook is presented in Table 10. The sample of radio-tagged chinook was smaller than anticipated and the actual chinook distribution was more extensive than illustrated. Forty-six of the tagged chinook were tracked into the upper Yukon drainage above the Stewart-Yukon confluence. Of this total, nineteen were tracked to tributary spawning areas, two were located in suspected mainstem spawning areas on the

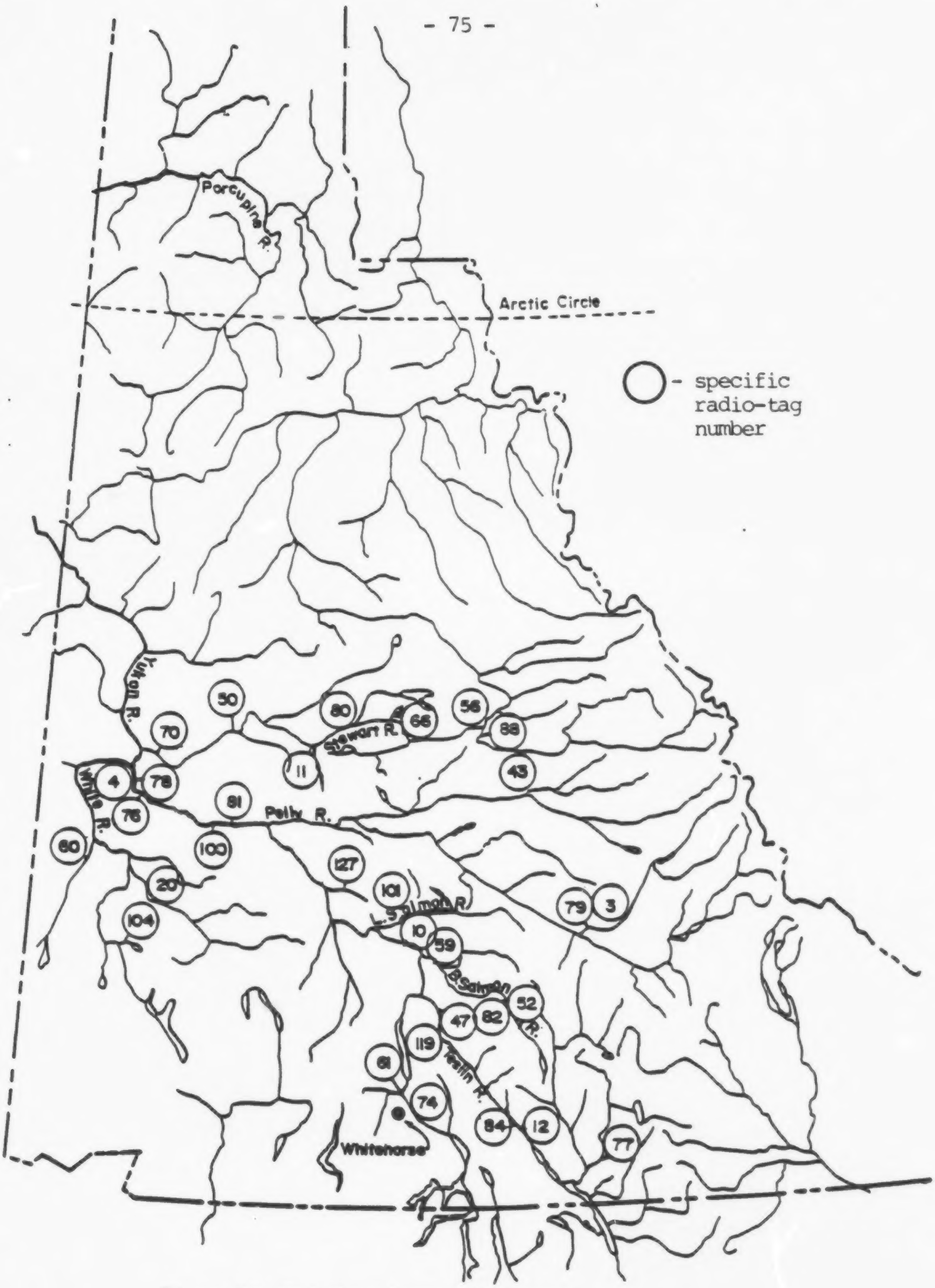
Porcupine R.
Arctic Circle
- specific radio-tag number
Yukon R.
White R.
Stewart R.
Pelly R.
L. Salmon R.
B. Salmon R.
Teslin R.
Whitehorse
50
80
66
56
88
70
11
43
4
78
81
76
60
100
127
20
101
79
3
104
10
59
52
47
82
119
61
74
84
12
77

Figure 22 Relative chinook distribution in the upper Yukon River drainage as determined by the final locations of a number of radio-tagged chinook.

Table 10 Summary of radio-tagged chinook recaptured in commercial and subsistence fisheries in mainstem Yukon River

Fish No.	Migration Rate km/hr Yukon	*	Date Tagged	Date Caught	Recorded Trav. time (days)	Final Obs. (km)	Distance Trav. from tag. site(km)	Comments
13	2.22	2	09/07/83	15/07/83	6	272	268	caught near Thistle Ck.( )
46	2.06	8	18/07/83	01/08/83	14	546	464	caught near Carmacks (N)
48	1.86	5	18/07/83	02/08/83	15	530	448	caught near Carmacks (N)
28	1.70	3	12/07/83	17/07/83	5	257	175	caught near Stewart Is(
73	1.65	11	23/07/83	03/08/83	11	514	432	caught near Carmacks (N
89	1.96	9	26/07/83	04/08/83	9	556	421	caught near Carmacks (N)
127	1.36	8	08/08/83	20/08/83	12	491	409	caught in plum of Tatchun Ck. (N)

Mean 1.83

Range 1.36 - 2.22

* No. of Observations

** Estimated Date

(N) Caught in native subsistence fishery

(C) caught in commercial fishery

Yukon River, eight were lost within tributaries, four were captured in commercial and subsistence gillnets along the mainstem Yukon, and five were thought to have died during migration. Forty-nine of the tagged chinook were caught in the commercial fishery in the Dawson area, twelve exhibited downstream movements, and eighteen chinook regurgitated their transmitters or died from tag-induced injuries, migratory delay, or gillnet induced injuries (net dropouts).

The distribution of tagged chinook within each sub-basin is described in the following sections. As indicated in section 1.1 and Table 10, the study area included five sub-basins, as follows:

- mainstem Yukon River
- Stewart River
- White River
- Pelly River
- Teslin River

3.2.2.1 Mainstem Yukon

The mainstem Yukon is defined as the main channel of the Yukon River from the Yukon-Alaska boundary to its source in headwater lakes along the British Columbia-Yukon border. All sub-basins flow into the mainstem Yukon. For the purposes of this discussion, the mainstem Yukon was sub-divided into the following three components.

1. Lower Yukon Mainstem - downstream of Stewart-Yukon confluence including the Klondike River.

2. Mid-Yukon Mainstem - Stewart-Yukon confluence to Hootaglinqua. This area also includes the following tributaries: Tatchun Creek, Little Salmon River, Big Salmon River, Nordenskiold River.

3. Upper Yukon Mainstem - upstream of Hootalinqua including the Takhini River.

Lower Yukon Mainstem

Two radio-tagged chinook were tracked into the Fortymile River, a tributary of the lower Yukon mainstem. The entry of these fish into the Fortymile River was thought to be tag induced. Both fish left the Fortymile River without spawning.

Previous studies documented chinook spawning in three areas of the lower Yukon mainstem (Elson and Steigenberger 1977), and in a number of tributaries of the lower mainstem Yukon, including the Fortymile River, Coal Creek, Fifteenmile River, Chandindu River, and the Klondike River (DFO files). A small chinook return was observed in the Klondike River, and returns to other tributaries were assumed to be minimal. These tributaries were expected to be more important for rearing than spawning.

Mid-Yukon Mainstem

Of the 46 chinook that migrated into tributaries of the Yukon River, 21 (45.6%) entered tributaries along the mid-Yukon mainstem, of which eight entered confirmed or suspected spawning areas. These include Tatchun Creek, Little Salmon River, Big Salmon River, and spawning areas in the Yukon River.

Tatchun Creek is a small creek 6 km in length which drains Tatchun Lake and enters the Yukon River approximately 350 km upstream of Dawson City. One radio-tagged chinook was caught in a subsistence fishery gillnet located within the plume of Tatchun Creek. This fish was oriented in the water from Tatchun Creek and it is assumed that Tatchun Creek was its spawning destination. This fish was tagged on August 8 and was captured on August 29th.

The Little Salmon River flows approximately 56 km from Little Salmon Lake to its confluence with the Yukon River 442 km upstream of Dawson City. Two radio-tagged chinook spawned in the Little Salmon River (Table 11; Figure 23). These fish were tagged July 7 to July 31 and entered the Little Salmon on July 28

Table 11 Migration rates of chinook destined for Little Salmon River

	MIGRATION RATE (km/hr)								
FISH NUMBER	YUKON	*	LITTLE SALMON	*	DATE TAGGED	LITTLE SALMON RIVER ARRIVAL DATE	RECORDED TRAVEL TIME (DAYS)	FINAL OBS. (KM)	DISTANCE TRAVELLED FROM T. SITE (KM)
10	1.40	13	0.20	1	07/07/83	28/07/83	29**	619	537
101	1.75	5	-		31/07/83	18/08/83	19	609	527
Mean	1.58		0.20						
Range	1.40-1.75		0.20						

* Number of observations

** Estimated

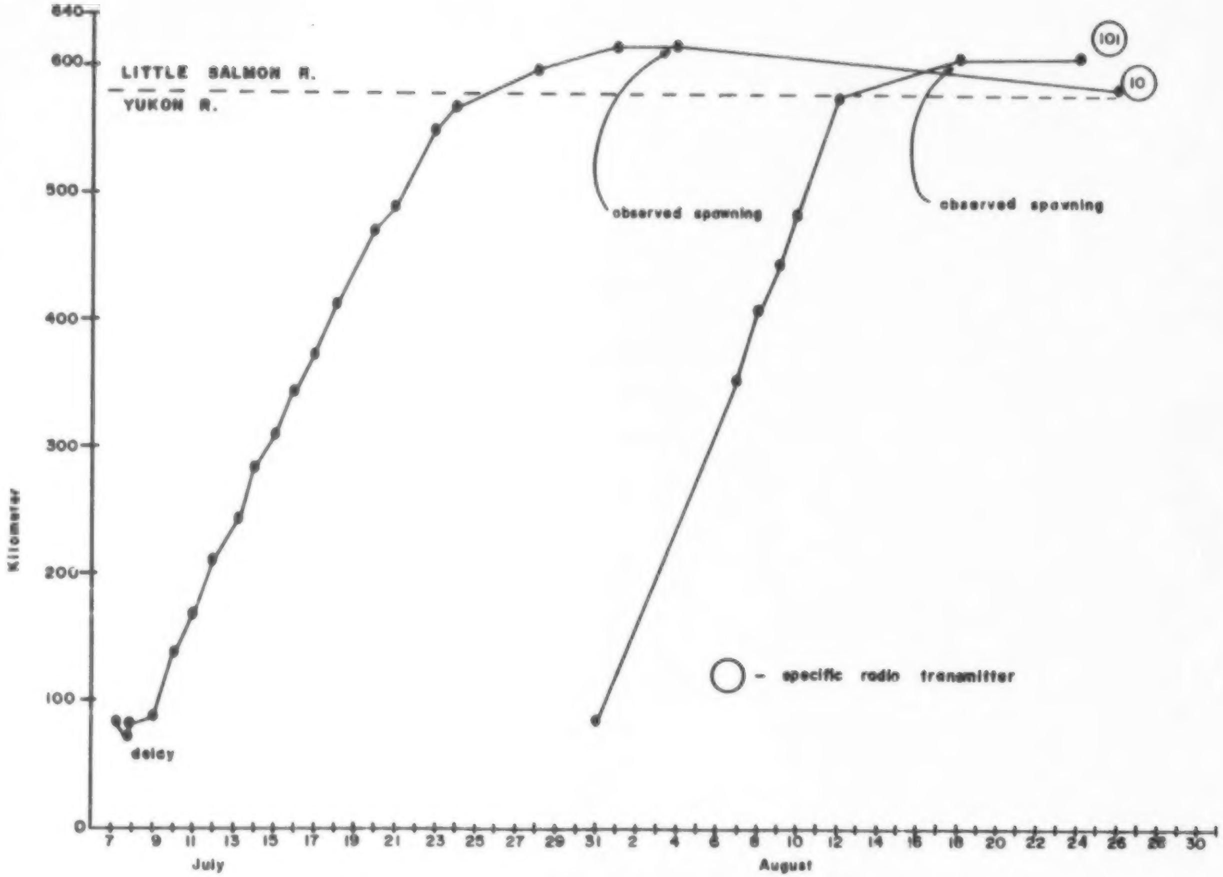

Figure 23 Radio tracking records of chinook salmon bound for the Little Salmon River, 1983. Distances shown are from the lowest tagging site.

and August 18, respectively. These entry dates represent the temporal extremes of migration into this system. Few fish were present on the spawning grounds on July 28 when the first tagged fish entered Little Salmon River. The second tagged fish entered the river four days after peak spawning occurred on August 14.

The Big Salmon River flows 220 km from Quiet, Sandy, and Big Salmon Lakes to its confluence with the Yukon River 500 km upstream of Dawson City. Three radio-tagged chinook (numbered 52, 59, and 82) spawned in the Big Salmon River (Table 12; Figure 24). These fish were tagged July 19 to 25 and entered the Big Salmon August 2 to 9. One fish entered early in the run while the other two entered during the latter portion of the run. Fish number 52 spawned immediately below Quiet Lake while fish numbers 59 and 82 spawned approximately 50 km below Quiet Lake. The first observations of spawning activity on the Big Salmon were made in the area immediately below Quiet Lake. This was followed by a progressive increase in spawning activity downstream from this point. There appeared to be two discrete periods of spawning activity in the area below Quiet Lake. The first period occurred August 1 to 7. Several lone females on redds were observed on August 14th. The second spawning period occurred during the last week of August when a large concentration of spawning pairs was observed in the same area.

Two radio-tagged chinook (numbered 81 and 100) were tracked to suspected spawning areas along the mid-Yukon mainstem (Table 13, Figure 25). These fish were tagged on July 25 and 30 and both stopped upstream migration on August 9.

The migration pattern of fish number 81 was interesting. Mean migration rates of 1.55 and 0.89 $km.h^{-1}$ were recorded between km 100 and km 182 and between km 182 and km 220, respectively. The decrease in the latter rate coincided with increasing water levels, primarily from the White River. This fish stopped its upstream movement and held at km 226 for a 24 hour period. Its migration rate increased above the Yukon-White confluence then decreased as the fish approached km 384 (Figure 25). The radio tag was recovered on

Table 12 Migration rates of chinook destined for Big Salmon River

FISH NUMBER	MIGRATION RATE (km/hr)				DATE TAGGED	BIG SALMON RIVER ARRIVAL DATE	RECORDED TRAVEL TIME (DAYS)	FINAL OBS. (KM)	DISTANCE TRAVELLED FROM T. SITE (KM)
	YUKON	*	BIG SALMON	*					
52	1.65	8	0.70	1	19/07/83	02/08/83	27	835	753
59	1.35	10	1.19	1	21/07/83	08/08/83	19	649	567
82	1.63	7	1.93	2	25/07/83	09/08/83	18	793	711
Mean	1.54		1.27						
Range	1.35-1.65		0.70-1.93						

* Number of observations

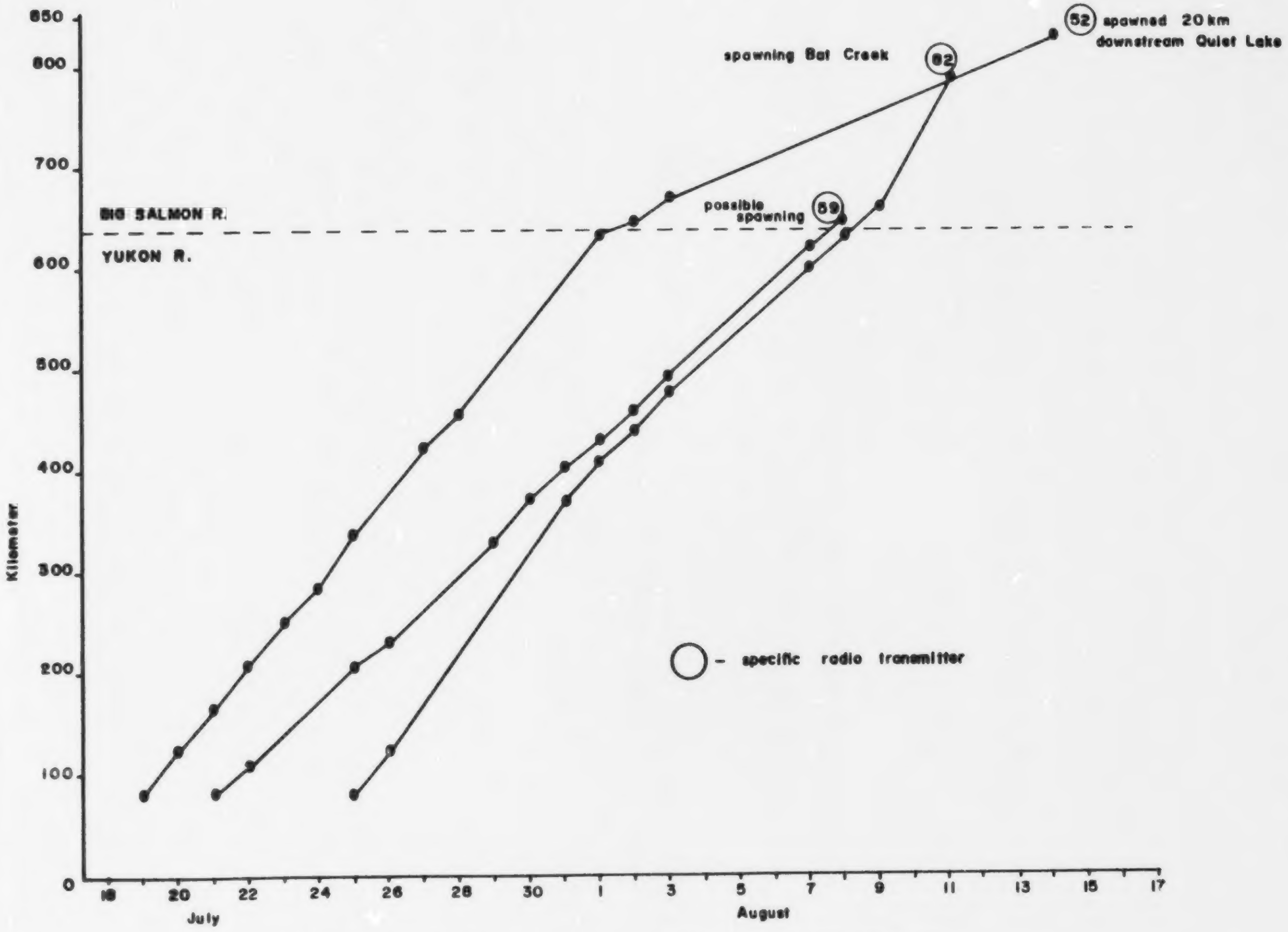

Figure 24 Radio tracking records of chinook salmon bound for the Big Salmon River, 1983. Distances shown are from the lowest tagging site.

Table 13 Migration rates of chinook destined for the mainstem Yukon

FISH NUMBER	MIGRATION RATE (KM/HR)		DATE TAGGED	ARRIVAL DATE	RECORDED TRAVEL TIME (DAYS)	FINAL OBS. (KM)	DISTANCE TRAVELLED FROM T. SITE (KM)
	YUKON	*					
81	1.00	12	25/07/83	09/08/83	14	384	302
100	1.13	4	30/07/83	09/08/83	9	352	270

Mean 1.06

Range 1.00-1.13

* Number of observations

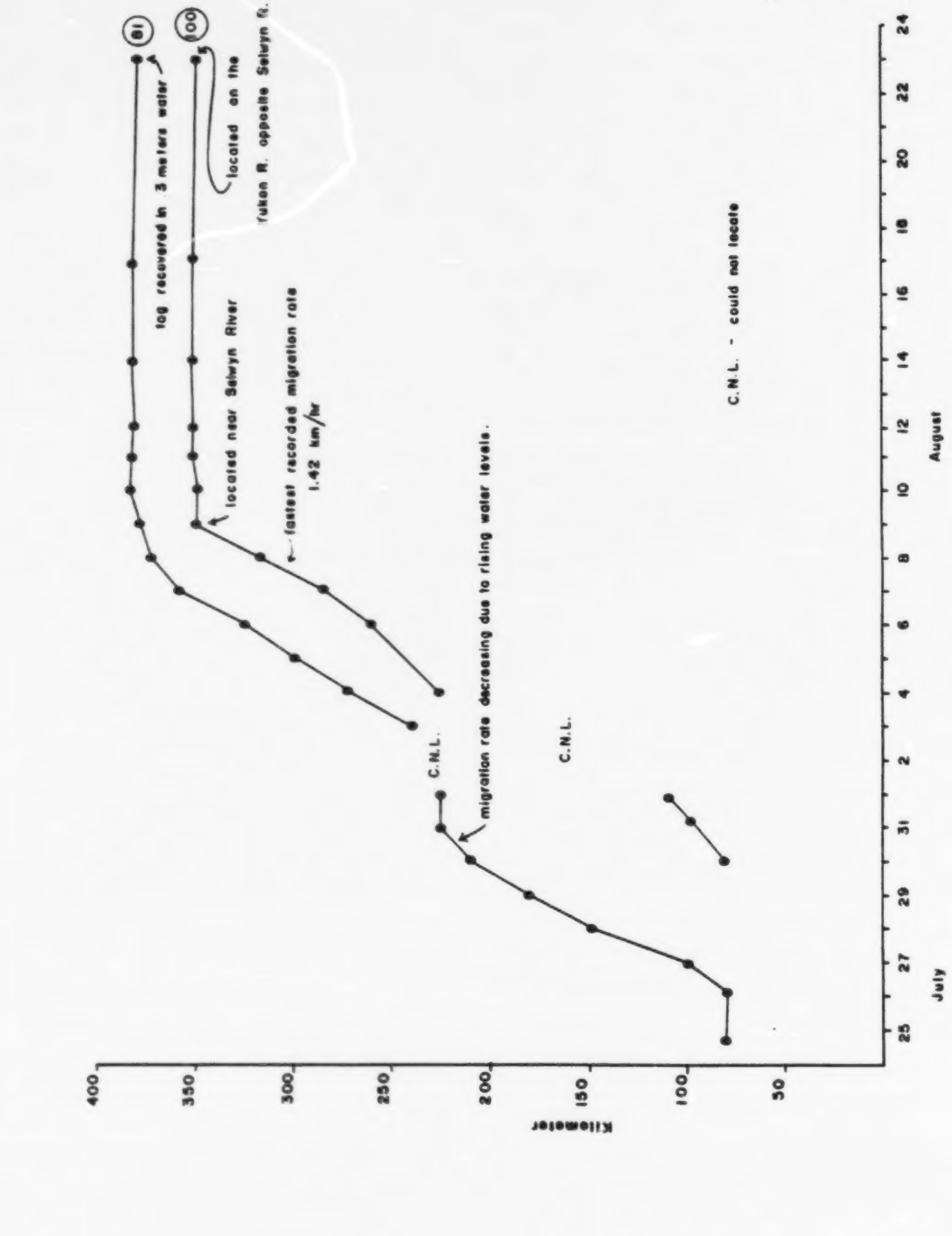

Figure 25 Radio tracking records of chinook salmon bound for suspected mainstem spawning areas, 1983. Distances shown are from the lowest tagging site.

August 23rd at km 384 in approximately 0.3 m of water. The radio tag was not in the fish. Although spawning chinook were not observed in the immediate area, spawning probably occurred on the inside channel of an island located at km 383, where an ice-free area fed by upwelling groundwater was previously identified.

The second fish (number 100) was tracked to a suspected mainstem spawning area where it stopped its upstream migration opposite the mouth of the Selwyn River at km 352 (Figure 25). Chinook spawning was not observed in the immediate area, but, one chinook was observed (jumping) on August 23.

The importance of mainstem spawning may have been underestimated by the two radio-transmitters tracked to suspected spawning areas. A number of documented mainstem spawning locations near Minto support what is believed to be a significant chinook spawning area (Walker 1976). Similar spawning areas probably occur throughout other parts of the mainstem Yukon. Spawning counts in mainstem areas are precluded by turbidity and the depth of the water. Indices of abundance are limited to counts of "breaching" chinook and the presence of carcasses. There are a number of explanations for the small sample of radio-tags which stopped in mainstem spawning locations. These include:

- an incomplete sample period;
- the state of sexual maturity of the fish;
- the size and migratory behaviour of mainstem spawners;
- a below average cycle year return.

The sample period was incomplete because the program was terminated on August 9 when chinook were still migrating through the Dawson area. The portion of the chinook run after this date could have consisted primarily of chinook bound for mainstem spawning areas. Based on a mean migration rate of 38 km.day^{-1}, chinook tagged on August 9 would have reached the Minto area (km 440) in 12 days. This would place them in spawning areas after the 19th of August. The time frame coincides with observations made during ground surveys in the Minto area that chinook abundance increased between August 20th and August 23rd.

Many of the chinook tagged during the latter portion of the run were in an advanced state of sexual maturity, which was evident from external morphological characteristics that included deep red coloration, well developed kype, eroded and frayed fins, fungal infections, and the distended ventral areas of gravid females. The advanced condition of the fish was one of the reasons why the tagging portion of the program was terminated on August 9. Since mainstem spawning areas were located closest to the tagging sites, it was reasonable to assume that many of the "advanced" fish were bound for these areas. The fish that exhibited advanced external characteristics may also have had advanced atrophy of the gut tissue, which could have contributed to tag-induced injuries or mortalities because any transmitters that had been applied probably would have slipped through the gut lining. Fish number 116, for example, died from a lacerated liver and spleen caused by the antennae of the transmitter after the transmitter had slipped through the gut lining. Similar mortalities could explain the low number of radio-tagged fish that reached mainstem spawning areas.

Mainstem chinook are significantly larger than those which spawn in tributaries (Brock 1976; Walker 1976). A number of the larger chinook salmon migrated at greater water depths as was evident from the reduced intensity of radio signals, particularly during low water levels. In many cases, signals were undetectable. Similarly, many local fishermen stated that the largest chinook were caught in the deepest part of their gillnets, often near the leadline. Since fishwheels were selective for small chinook of the lower age classes (Sweitzer 1974; Brock 1976), it was assumed that many of the larger mainstem-bound chinook may not have been captured by the fishwheels.

The final, and perhaps the simplest, explanation for the low number of mainstem spawners is a below average return to mainstem areas in 1983. Since there is no way of quantitatively assessing the number of mainstem spawners, it is not possible to determine annual run strength.

Upper Yukon Mainstem

Of the 46 chinook that migrated into tributaries of the Yukon River, two (4.3%) entered the upper Yukon mainstem (Table 14, Figure 26). These fish were tagged on July 21 and July 23 and entered this area on August 15 and August 11, respectively.

One of these fish (number 61) was captured in a susbsistence fishery gillnet located 0.5 km below the Takhini-Yukon confluence. Since this fish had orientated on the left bank[1] in the plume of the Takhini River, it was assumed that this tributary was its spawning destination. This fish exhibited erratic behaviour throughout its migration. It moved 15 km downstream of the tagging site and held there for five days following transmitter implantation.

The second fish (number 74) migrated as far as the Whitehorse Rapids Dam, but did not ascend the Whitehorse Fishway. Spawning occurred in a previously undocumented area located approximately .5 km upstream of the Robert Campbell bridge at Whitehorse. Spawning was confirmed by the presence of "breaching" chinook and carcasses with eroded tails. Spawning activity below the Whitehorse Rapids Dam may have occurred in 1983 as a result of several factors, including the following:

- high water levels
- high spillway discharge
- migratory delay associated with the high water levels and the fishway facility.

Fish number 74 held below the fishway entrance for approximately 24 hours before moving 2 km downstream, where it remained for 17 days (Figure 27). Seventy chinook were observed holding in eddies and slack-water areas below the dam site on August 15. In total, an estimated 250 to 300 chinook, all in an advanced

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[1] River banks are identified as left and right banks from the point of view of an observer facing downstream.

Table 14 Migration rates of chinook destined for upper Yukon River above Lake LaBerge

FISH NUMBER	MIGRATION RATE (km/hr) YUKON	*	DATE TAGGED	ARRIVAL DATE	RECORDED TRAVEL TIME (DAYS)	FINAL OBS. (KM)	DISTANCE TRAVELLED FROM T. SITE (KM)
61	1.30	17	21/07/83	Yukon-Takhini Confluence 18/08/83	29	801	719
74	1.38	18	23/07/83	Whitehorse Fishway 14/08/83	41	826	744
Mean	1.34						
Range	1.30-1.38						

* Number of observations

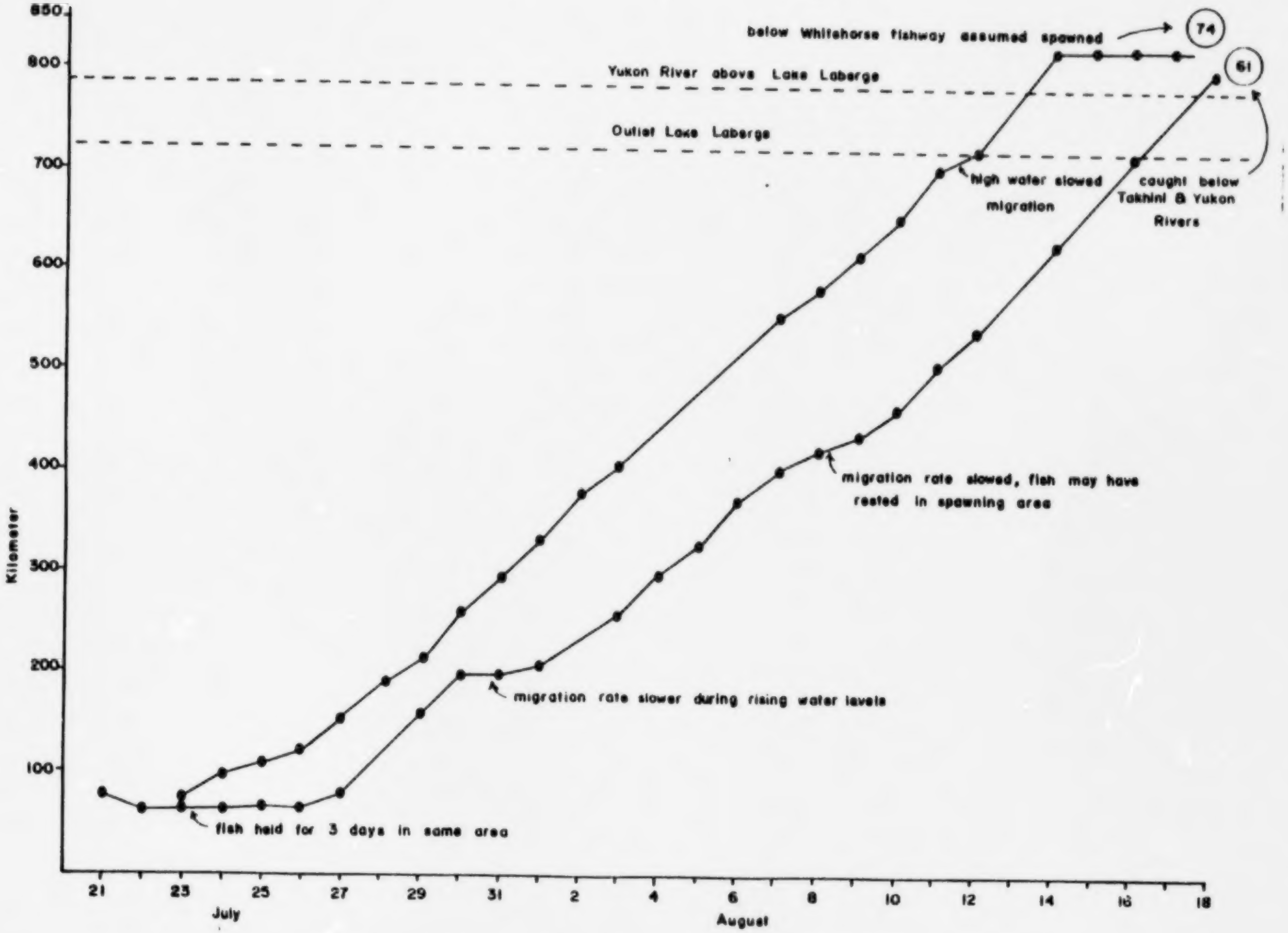

Figure 26 Radio tracking records of chinook salmon bound for the upper Yukon mainstem, 1983. Distances shown are from the lowest tagging site.

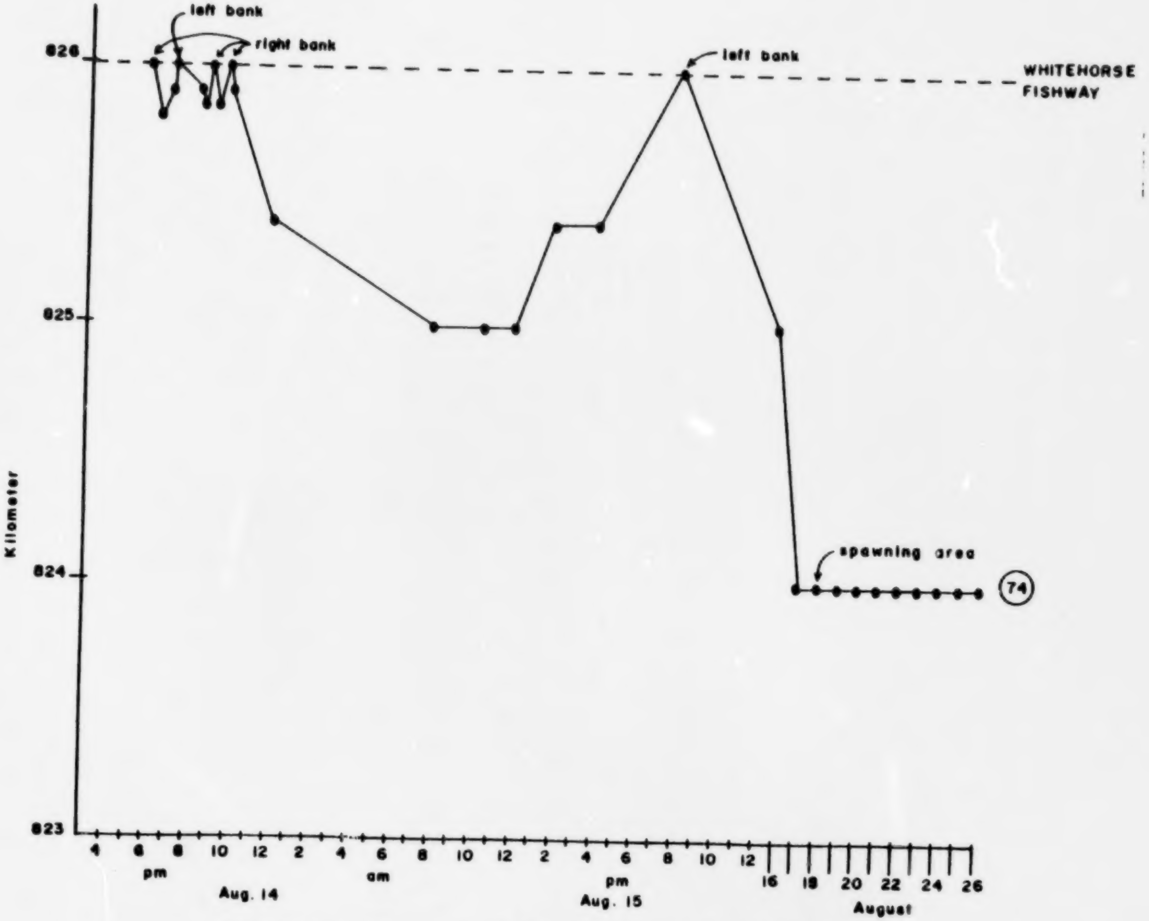

Figure 27 Movement of a radio-tagged chinook below the Whitehorse Fishway, 1983. Distances shown are from the lowest tagging site.

state of maturity, held below this facility. Spawning below the dam site may have been induced by the migratory delay associated with high water conditions and/or the operating schedule of the fishway, which was not manned on a 24-hour basis. Fish that ascended the fishway during the night could not clear the facility because the gates in the holding chamber remained closed.

In addition to the two spawning areas identified as the result of the radio-tracking, an additional three spawning areas in the upper Yukon mainstem were identified by previous studies. The principal chinook spawning area in the Yukon watershed above Whitehorse is Michie Creek, a tributary of the McClintock River (Cleugh and Russel 1980). Low or infrequent spawning returns have been reported in the Ibex River, a tributary of the Takhini River, and at the mouth of McIntyre Creek. Potential spawning areas include mainstem locations between Lake Laberge and Marsh Lake, the outlet of Lake Laberge, Arkell Creek, and the Atlin and Tutshi Rivers in the British Columbia portion of the drainage (Figure 28; Brown et al. 1976; Foothills Pipeline Ltd. 19). Spawning chinook were observed in Wolf Creek in the mid-1970's, however, access to this system may be prevented by a number of beaver dams. The upper Yukon mainstem does not appear to be a major producer of chinook salmon at the present time, however, this area has good enhancement potential.

3.2.2.2 Stewart Sub-basin

The Stewart River originates in the Hess Mountains along the Yukon-Northwest Territories border and flows westward for approximately 640 km before joining the Yukon River 100 km upstream of Dawson City. Major tributaries of the Stewart include the Hess, Rogue, Nadaleen, Beaver, Lansing, Mayo, and McQuesten Rivers.

Of the 46 chinook that migrated into tributaries of the Yukon River, eight (17.4%) entered the Stewart sub-basin (Table 15, Figure 29). These fish were tagged between July 8 and July 26 (six after July 18) and entered the Stewart River between July 14 and August 7. Peak spawning occurred in mid-August.

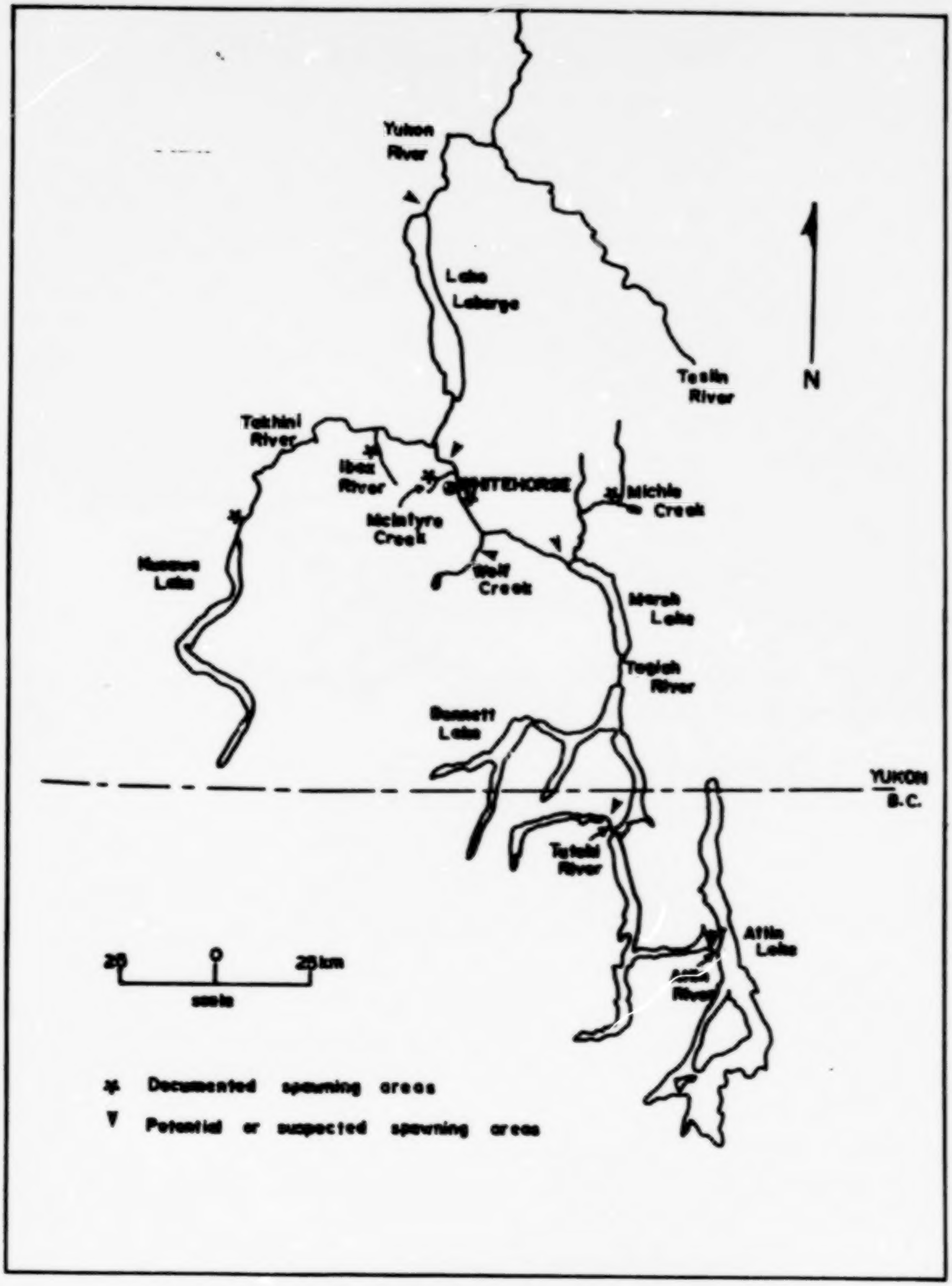
Yukon River
Lake Laberge
Teslin River
N
Takhini River
Ibex River
Whitehorse
McIntyre Creek
Michie Creek
Kusawa Lake
Wolf Creek
Marsh Lake
Tagish River
Bennett Lake
YUKON
B.C.
Tutshi River
Atlin Lake
Atlin River
20
0
20km
scale
Documented spawning areas
Potential or suspected spawning areas

Figure 28 Documented and suspected spawning locations in the upper Yukon mainstem.

Table 15 Migration rates of chinook destined for Stewart sub-basin

FISH NUMBER	MIGRATION RATE (km/hr)				DATE TAGGED	SUB-BASIN ARRIVAL DATE	RECORDED TRAVEL TIME (DAYS)	FINAL OBS. (KM)	DISTANCE TRAVELLED FROM T. SITE (KM)
	YUKON	*	STEWART	*					
11	1.98	4	2.04	2	08/07/83	14/07/83	9	354	350
43	1.54	2	1.78	2	17/07/83	22/07/83	28	534	452
50	1.85	2	1.50	1	19/07/83	23/07/83	6	282	200
56	1.68	3	2.00	1	20/07/83	24/07/83	18	493	411
66	1.74	5	2.22	1	22/07/83	27/07/83	8	400	318
70	1.30	7	0.82	1	22/07/83	31/07/83	23**	253	249
80	1.66	3	1.93	1	25/07/83	08/08/83	20	363	281
88	2.01	2	2.44	1	26/07/83	29/07/83	19**	500	365
Mean	1.72		1.84						
Range	1.30-2.01		0.82-2.44						

* Number of observations

** Estimated

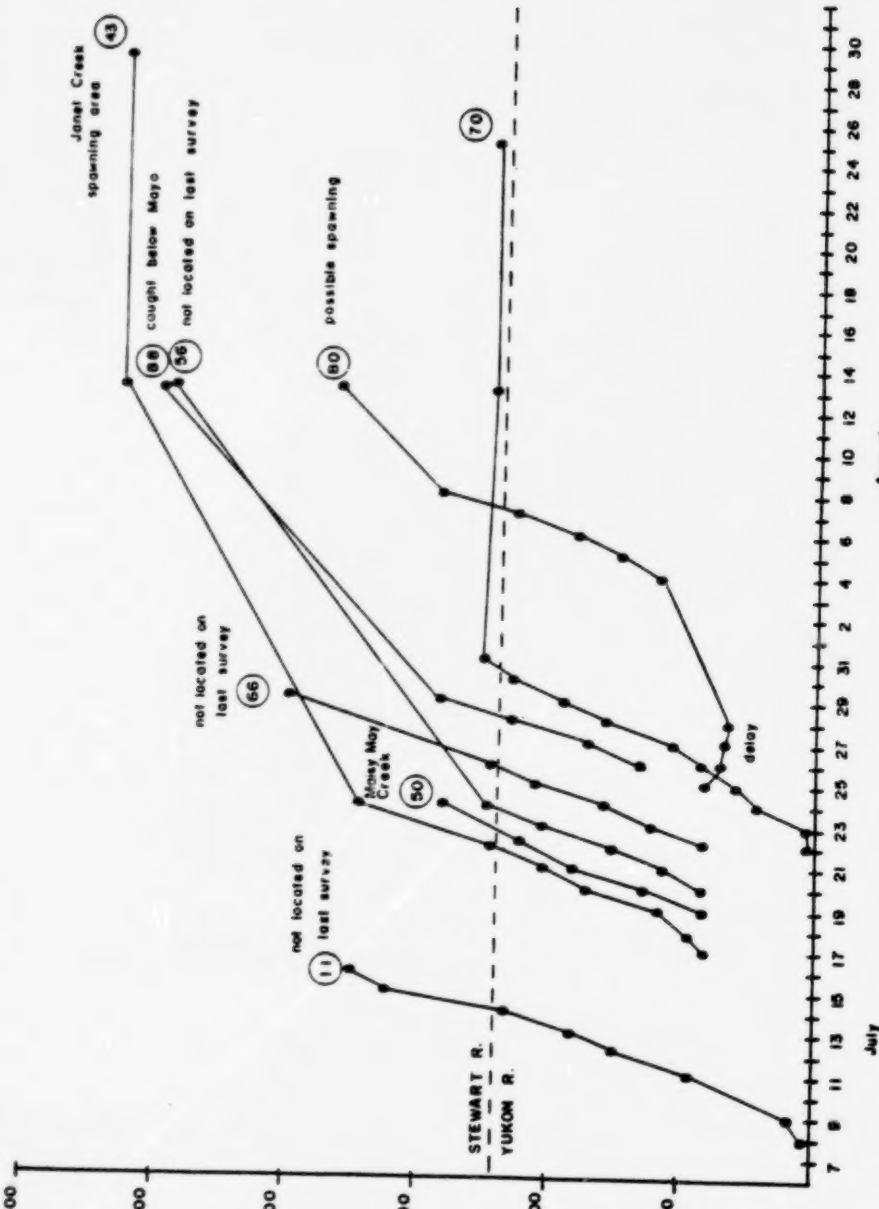

Figure 29 Radio tracking records of chinook salmon bound for the Stewart sub-basin, 1983. Distances shown are from the lowest tagging site.

Documented spawning areas within the Stewart River watershed are located 200 to 600 km above the Stewart-Yukon confluence. Radio-tagged chinook were widely distributed in the mainstem and tributaries throughout the watershed. One radio-tagged chinook spawned in Janet Creek, approximately 300 km above the Stewart-Yukon confluence. Another three were tracked to mainstem locations 13, 123, and 253 km above the Stewart-Yukon confluence. Spawning was not confirmed in the mainstem locations. One radio-tagged chinook was captured in a native subsistence fishery located below the townsite of Mayo. Three radio-tagged chinook were tracked into the Stewart sub-basin, however, the spawning destinations of these fish were not determined because of infrequent tracking flights.

The distribution of chinook salmon within the Stewart sub-basin appears to be more extensive than was indicated by the radio-tracking results. Ennis _et_ _al_. (1982) reported that spawning occurs in the McQuesten, Beaver, Mayo, Lansing, Hess, and Pleasant Rivers, in Janet Creek, and in Crooked Creek. Recent spawning information is available only for the Mayo, South McQuesten, and Beaver Rivers where observed escapements have totalled less than one hundred chinook (DFO files). Several spawning areas are located above Fraser Falls. Elson (1974) suggested that Fraser Falls could present a barrier to migrating chinook salmon during years with low water levels, although this seems unlikely.

The Stewart sub-basin is probably the most poorly documented sub-basin within the study area. This has resulted primarily from the remoteness of many tributaries. Excellent spawning and rearing areas exist within this watershed, but it is difficult to assess the extent of chinook production because of difficulties in identifying mainstem spawning areas, and the lack of consistent escapement monitoring for the system as a whole. Spaghetti-tag returns from the native subsistence fishery suggest that this sub-basin is an important producer of chinook salmon. In terms of chinook production relative to the other sub-basins, the Stewart sub-basin ranks higher than White sub-basin, but lower than the Pelly sub-basin.

3.2.2.3 White Sub-basin

The White River originates in the Kluane Range of the St. Elias Mountains and flows northward to its confluence with the Yukon River 130 km upstream of Dawson City. Major tributaries of the White River include the Donjek and Ladue Rivers. The Donjek River has three major tributaries, the Kluane, Misling, and Klotassin Rivers which flow in a northwestward direction. The Kluane River drains Kluane Lake, the largest lake in the Yukon Territory.

Of the 46 chinook which migrated into tributaries of the Yukon River, three (6.5%) entered the White sub-basin (Table 16, Figure 30). These fish were tagged between July 9 and August 1 and entered the mouth of the White River between July 17 and August 10.

The distribution of radio-tagged chinook corresponds with documented spawning areas within this watershed. One radio-tagged chinook spawned in the Nisling River, 20 km above its confluence with the Donjek River, and another spawned in Tincup Creek, 5 km above its confluence with the Kluane River. Spawning had been previously documented in both tributaries, but not in the locations where the radio transmitters were located. Another chinook was tracked to km 140 of the White River, but its spawning destination was not determined.

It is unlikely that chinook spawning occured in mainstem portions of the White, Donjek, or Kluane Rivers because high levels of suspended solids and the changeable nature of river channels provided unsuitable habitat, and because chinook were not observed utilizing the clear spring-fed side channel areas along the mainstem where chum spawning occurred. A limited amount of chinook spawning may occur at the outlet of Kluane Lake. The distribution of chinook salmon in the White sub-basin is probably confined to clear runoff streams similar to the habitat where the radio-tagged chinook spawned.

The White sub-basin did not appear to be an important producer of chinook salmon because of a lack of good spawning and rearing habitat. This sub-basin has received low priority in terms of escapement surveys and fisheries research. Since

Table 16 Migration rates of chinook destined for White sub-basin

FISH NUMBER	MIGRATION RATE (km/hr)				DATE TAGGED	SUB-BASIN ARRIVAL DATE	RECORDED TRAVEL TIME (DAYS)	FINAL OBS. (KM)	DISTANCE TRAVELLED FROM T. SITE (KM)
	YUKON	*	WHITE	*					
20	1.09	1	0.80	4	09/07/83	17/07/83	53	438	356
60	1.39	3	0.31	1	21/07/83	25/07/83**	33	406	324
104	1.42	5	0.51	2	01/08/83	10/08/83**	30	561	479

Mean 1.19 0.54

Range 1.09-1.39 0.31-0.80

* Number of observations

** Estimated

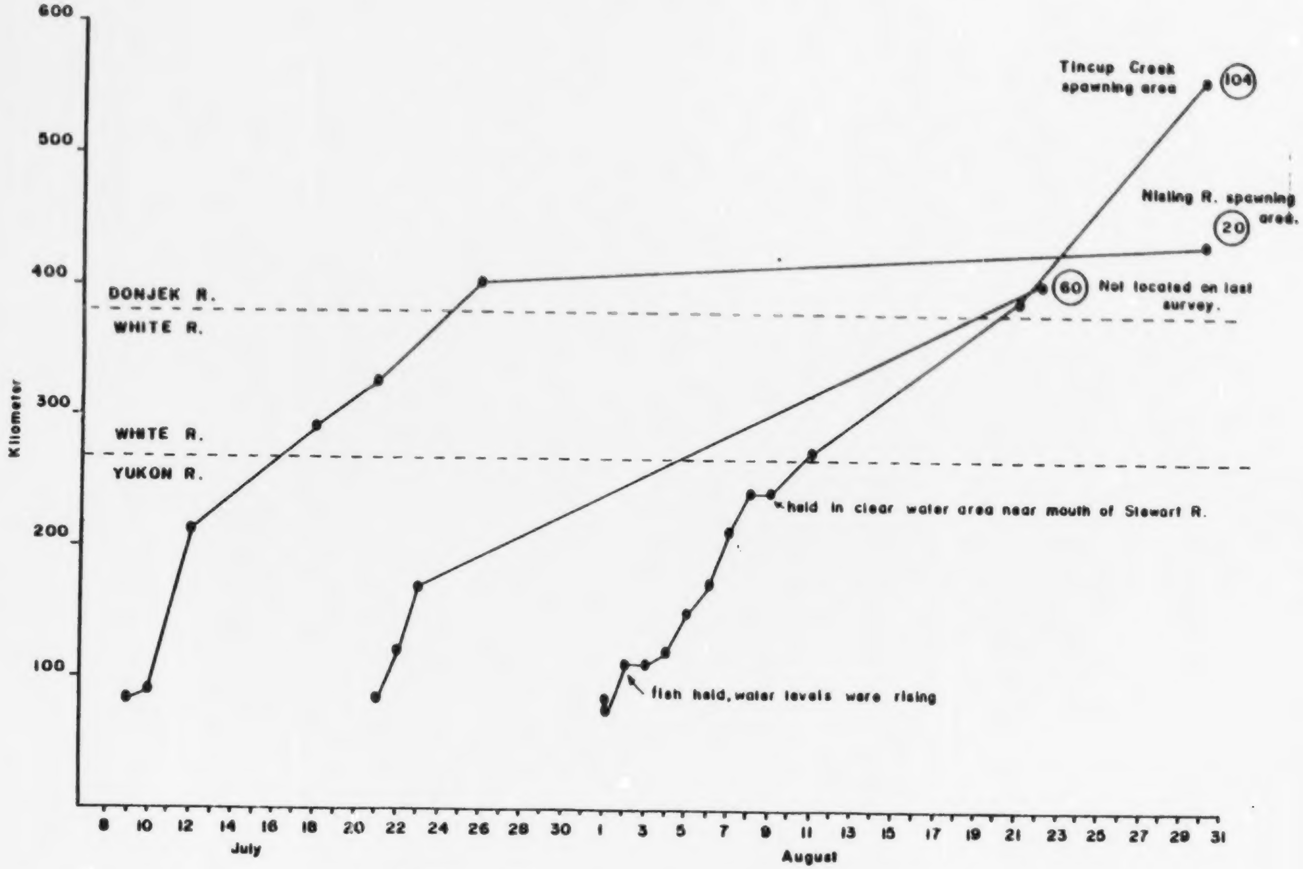

Figure 30 Radio tracking records of chinook salmon bound for the White sub-basin, 1983. Distances shown are from the lowest tagging site.

the spawning areas identified involve clear water, escapement surveys conducted by helicopter could determine the level of chinook production within the sub-basin.

3.2.2.4 Pelly Sub-basin

The Pelly River originates in the Selwyn Mountains along the Yukon/Northwest Territories border and flows westward to its confluence with the Yukon River 260 km upstream of Dawson City. Major tributaries include the MacMillan, Ross, Hoole, Lapie, Tay, and Kalzas Rivers.

Of the 46 chinook which migrated into tributaries of the Yukon River, five (10.9%) entered the Pelly sub-basin (Table 17, Figure 31). Two were tagged on July 6 and three on July 25; they entered the Pelly River between July 15 and August 6. Peak spawning occurred in mid-August.

Three of the five chinook were captured in native subsistence fisheries, two between Bradens Canyon and Pelly Crossing and the third at Ross River. The fourth fish was located in a spawning area in the Ross River. The final location of the fifth fish was not determined.

The distribution of chinook salmon in the Pelly sub-basin is obviously more extensive than indicated by the radio tracking results. A total of 14 chinook spawning areas identified during previous studies in this sub-basin (Ennis et al. 1982; DFO files), include the principal spawning areas at the Ross River (the destination of one radio-tagged chinook) and the South MacMillan River. The status of many of the known spawning areas has not been updated in recent years and the extent of mainstem spawning has not been determined.

The Pelly sub-basin is an important producer of chinook salmon. It ranks higher than both the Stewart and White sub-basins.

Table 17 Migration rates of chinook destined for Pelly sub-basin

FISH NUMBER	MIGRATION RATE (km/hr)				DATE TAGGED	SUB-BASIN ARRIVAL DATE	RECORDED TRAVEL TIME (DAYS)	FINAL OBS. (KM)	DISTANCE TRAVELLED FROM T. SITE (KM)
	YUKON	*	PELLY	*					
3	1.70	11	1.85	2	06/07/83	15/07/83	40	827	745
4	0.96	12	0.97	1	06/07/83	21/07/83	18	412	330
76	2.19	6	2.84	1	25/07/83	31/07/83	14**	446	364
78	1.55	8	2.47	1	25/07/83	06/08/83	13	440	358
79***	-		-		25/07/83		17**	810	728
Mean	1.60		2.03						
Range	0.96-2.19		0.97-2.84						

* Number of observations

** Estimated

*** Tag frequency on insertions was in error from recovery tag

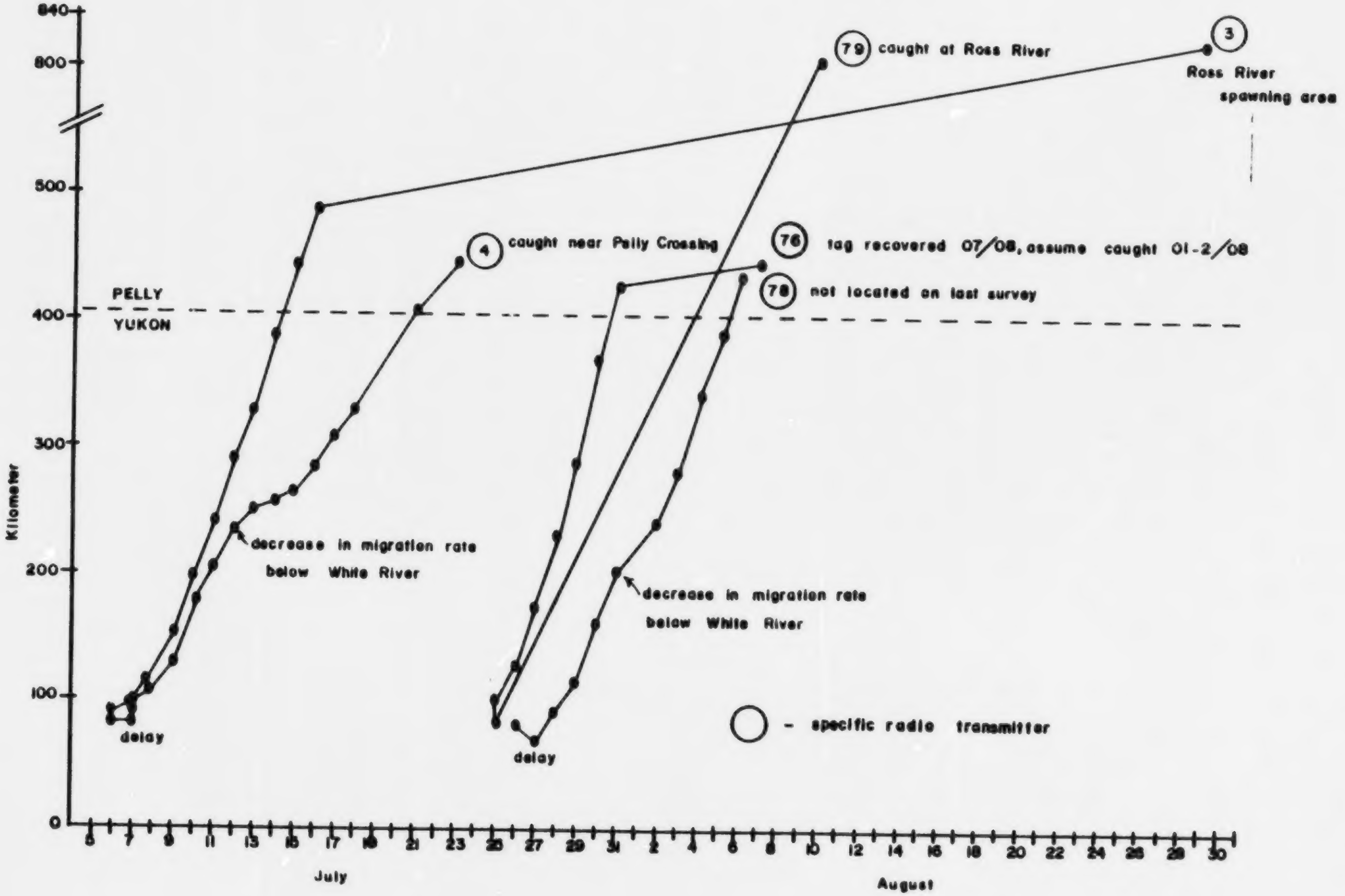

Figure 31 Radio tracking records of chinook salmon bound for the Pelly sub-basin, 1983. Distances shown are from the lowest tagging site.

3.2.2.5 Teslin Sub-basin

The Teslin River drains Teslin Lake, which straddles the Yukon/British Columbia border, and is the second largest lake in the Yukon Territory. From Teslin Lake, the Teslin River flows northwestward for 192 km to its confluence with the Yukon River at Hootalinqua. Major tributaries of the Teslin River include the Upper Teslin, Jennings, Hayes, Gladys, Morley, Swift, Nisutlin, and Wolf Rivers.

Of the 46 chinook that migrated into tributaries of the Yukon River, seven (15.2%) entered the Teslin sub-basin. Five entered the upper Teslin watershed above Teslin Lake (Table 18, Figure 32) and two were tracked to spawning areas in the mainstem Teslin River (Table 19, Figure 33). Peak spawning in the upper Teslin drainage occurred around mid-August. The five radio-tagged fish that entered the upper Teslin were tagged between July 8 and July 25 and they entered Teslin Lake from July 27 to August 14. Two spawned in the Nisutlin River, one of which was located in the Nisutlin River, 20 km above its confluence with Sidney Creek, while the other was located at the confluence of the Nisutlin and Sidney Creek. The last fish to enter the upper Teslin drainage spawned in the Morley River below Morley Lake and was recovered as a spawned-out carcass on September 2. Few fish were present in the spawning grounds and this fish appeared to have been dead for less than 48 hours. The two other radio-tagged chinook that entered the upper Teslin drainage were not located during final radio-tracking surveys. The three that spawned in the upper Teslin had migrated an average of 957 km from the tagging site and the total length of their freshwater migration averaged 3,000 km.

The two chinook that were tracked to spawning areas in the mainstem Teslin River were tagged on July 26 and August 6 and they entered the Teslin River on August 19 and August 24. One fish (number 84) spawned 4 km below Johnsons Crossing between August 20 and August 27 and by August 31 it had drifted downstream. The other fish (number 119) spawned after August 26, but the exact date and spawning location were not determined because of infrequent tracking surveys. Peak spawning in the mainstem Teslin occurred during the third week of August. Chinook carcasses and abandoned redds were observed on August 31 during an aerial survey, and five discrete mainstem spawning areas were identified in mainstem portions of the Teslin River.

Table 18 Migration rates of chinook destined for Teslin sub-basin

FISH NUMBER	MIGRATION RATE (km/hr) YUKON	*	TESLIN	*	DATE TAGGED	SUB-BASIN ARRIVAL DATE	RECORDED TRAVEL TIME (DAYS)	FINAL OBS. (KM)	DISTANCE TRAVELLED FROM T. SITE (KM)
12	1.94	10	1.85	3	08/07/83	27/07/83	20	874	869
30	1.89	8	2.21	1	12/07/83	30/07/83**	44	1067	985
47	1.59	10	2.29	1	18/07/83	06/08/83**	21	725	643
67	2.36	8	2.56	1	22/07/83	03/08/83**	34	1089	1007
77	1.72	12	1.32	1	25/07/83	10/08/83	37**	970	888
Mean	1.90		2.05						
Range	1.59-2.36		1.32-2.56						

* Number of observations

** Estimated

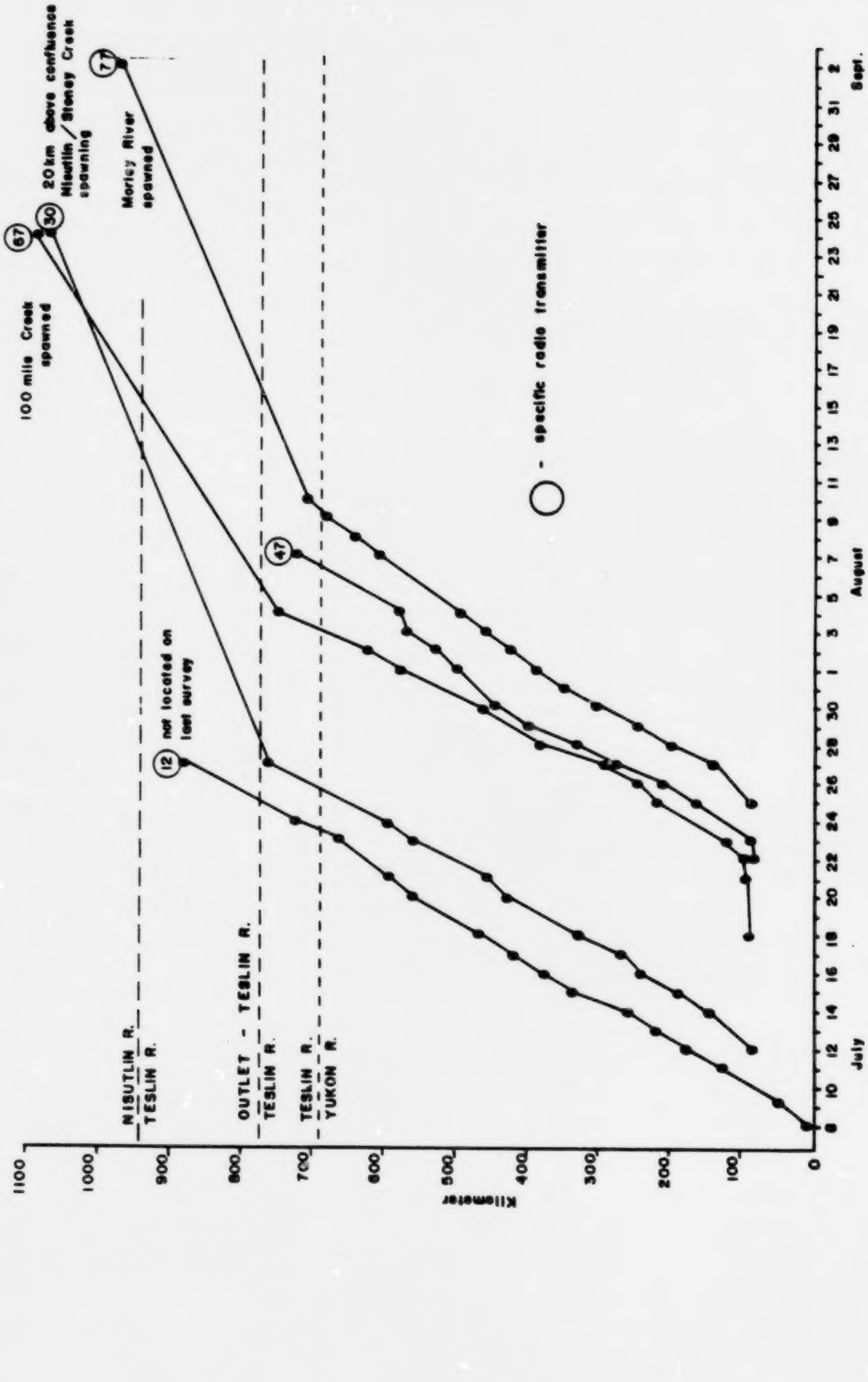

Figure 32 Radio tracking records of chinook salmon bound for the upper Teslin sub-basin, 1983. Distances shown are from the lowest tagging site.

Table 19 Migration rates of chinook destined for Teslin River mainstem

FISH NUMBER	MIGRATION RATE (km/hr) YUKON	*	TESLIN	*	DATE TAGGED	TESLIN RIVER ARRIVAL DATE	RECORDED TRAVEL TIME (DAYS)	FINAL OBS. (KM)	DISTANCE FROM T.SITE (KM)
84	1.14	19***	2.3	1	26/07/83	13/08/83	32	872	790
119	1.37	8	1.5	1	06/08/83	24/08/83**	21	756	674
Mean	1.26		1.89						
Range	1.14-1.37		1.50-2.30						

*Number of observations

**Estimated

***2 observations excluded - fish had stopped

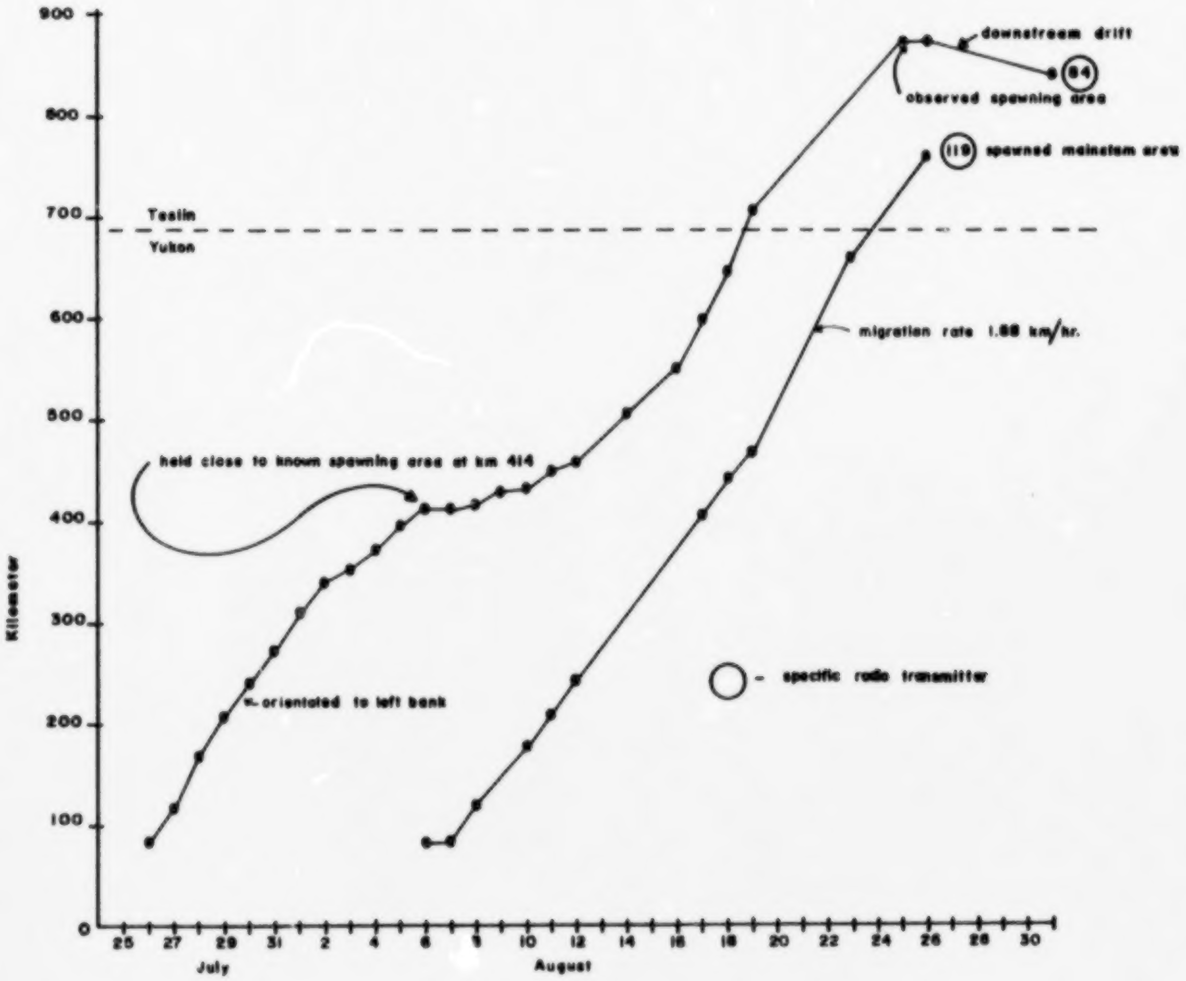

Figure 33 Radio tracking records of chinook salmon bound for the mainstem Teslin River, 1983. Distances shown are from the lowest tagging site.

Radio-tagged chinook were well distributed throughout the Teslin River mainstem and tributaries, however, the distribution of this species is more extensive than indicated by the radio tracking results. Previous studies in the area identified 21 spawning areas in tributaries and 5-10 spawning areas within the mainstem (Ennis *et al.* 1982; DFO files). The principal spawning areas were the Nisutlin River drainage and possibly the mainstem Teslin. Radio-tagged chinook were tracked to both areas in 1983. It was not possible during past and present studies to determine the extent of production in mainstem spawning areas, but the level of production was expected to be significant. A large number of the spawning areas identified in this sub-basin supported low spawning returns and many runs appeared to persist as remnants of larger historic populations.

3.2.3 Migration Rates and Migratory Behavior

This section provides information related to three aspects of the 1983 chinook migration: migration rates in the Yukon River mainstem, the migration behaviour of one particular fish, and the influence of discharge on migration rates. Each of these aspects is discussed separately, below. In general, the information on the tagging dates and tributary entry of radio-tagged chinook suggested that all of the tributary stocks migrated through the Dawson commercial fishery as a mixed stock during the same time interval. All of the radio-tagged chinook were tagged between July 6 and August 9, and they entered tributaries between July 14 and August 18. The migration timing of specific chinook stocks has important management implications with respect to the length of time they are subject to fishing activity (refer to section 2.2.7).

3.2.3.1 Migration Rates in Mainstem Yukon

Migration rates of chinook bound for the various tributaries are presented in Tables 11 to 19. The mean migration rate of all stocks in the mainstem Yukon was 36.2 km.day^{-1} (with a range of 16.8 to 56.6 km.day^{-1}),which was slightly greater than the rates of 30.9 km.day^{-1} in 1974 (Brock 1976) and 33.0 km.day^{-1} in 1982 (section 2.2.7) estimated by means of tag-recovery programs: and it was substantially greater than the 1983 spaghetti-tagging estimate of 24.6 km.day^{-1} (see section 2.2.7). The difference between the migration rates determined with spaghetti-tags and radio-tags appeared to be the result of the difference in the method used to calculate the rates. With spaghetti-tagging, migratory delay was included in the calculation because the migration rate was determined from the time elapsed between the release of the tagged fish and its recapture. Radio-tagging provided continuous migratory information, and migratory delay was excluded from the calculation of migration rates.

Chinook migration rates of 42.3 km.day^{-1} (Trasky 1973) and 48.3 to 77.4 km.day^{-1} (Alaska Department of Fish and Game 1963) were reported for Alaskan portions of the Yukon River. These rates were determined from tag and recovery programs.

The specific migration rates of fish in the mainstem Yukon bound for various tributaries are as follows:

Destination	Migration Rate (km.day^{-1}) while in the mainstem Yukon
Little Salmon River	37.9
Big Salmon River	37.0
upper Yukon mainstem	32.2
mainstem Teslin River	30.2
Teslin sub-basin (non-mainstem)	45.6
White sub-basin	28.6
Stewart sub-basin	41.3
Pelly sub-basin	39.8

3.2.3.2 Continuous Boat Tracking of Fish Number 2

A radio-tagged chinook (number 2) was continuously tracked by boat for 33 hours (Figure 34). This fish was a female with a fork length of 820.0 mm. The first attempt to implant a transmitter was difficult because of the size of the fish. The transmitter was not inserted far enough and it was regurgitated in the tagging box. The second attempt was successful. The fish moved downstream immediately after release and held in a shallow water area approximately 250 meters below the tagging site. At 10:30 a.m. the fish briefly surfaced. After holding for

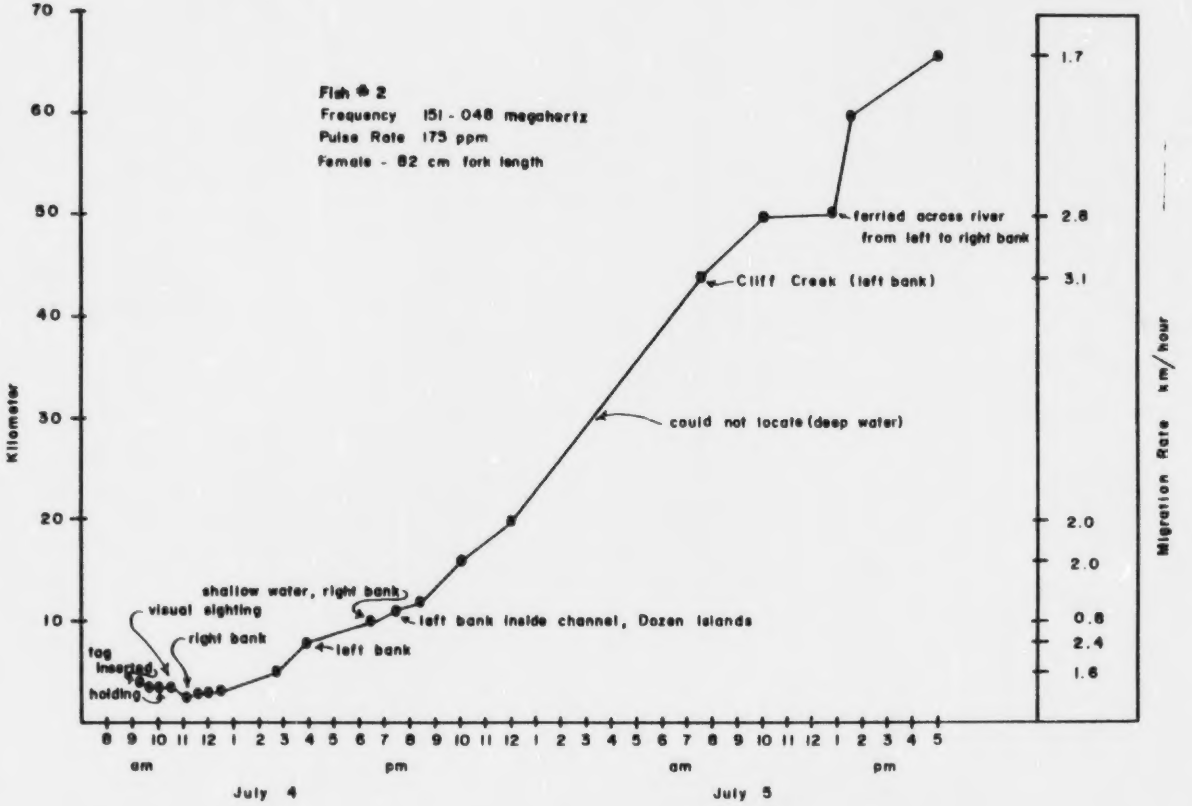

Figure 34 Boat tracking of a radio-tagged chinook over a 33 hour period. Distances shown are from the lowest tagging site.

approximately two hours, the fish crossed the river and proceeded upstream along the left bank. It consistently migrated at depths of 2.0 to 2.5 meters. These depths were estimated from the strength of the radio signals. The fish crossed at a bend in the river at km 8 and moved along the inside of an island located at km 10. It then crossed back to the left bank and moved through the inside channel of Dozen Islands (km 14 to 21). This channel had low water velocities and a minimum depth of 0.5 meters. The mean migration rate to this point was 1.6 $km.h^{-1}$ (range 0.8 to 2.4 $km.h^{-1}$). The fish continued to move along the left bank at a rate of 2.0 $km.h^{-1}$, until at km 44, it moved to the inside of the bend and continued its upriver migration at rates of 1.7 to 3.1 $km.h^{-1}$. It then crossed the river twice and was last observed on the left bank above the Fortymile River.

In summary, this fish continually migrated along the most energy-efficient path. It often avoided areas which had the highest water velocities by moving across to inside banks. It migrated along the shorelines of islands and used inside channels when they were available. Migration rates ranged from 0.8 to 3.1 $km.h^{-1}$.

3.2.3.3 Discharge Levels and Migration Rates

Three peak discharge periods, evident during the 1983 chinook run (Figure 35), appeared to result primarily from the White River discharge (Figure 36). Discharge levels for the Yukon River at Dawson in 1983 exceeded the levels from the previous two years.

The sediment load originating from the White River discharge was thought to have a negative influence on chinook migration rates in the mainstem Yukon. It was not possible to make a direct comparison between sediment loads and migratory rates as suspended solids levels were not determined; however, chinook migration rates were regressed against their proximity to the White River outflow. Regressions were calculated for minimum and peak White River discharge levels. Both regression lines indicated that an inverse relationship exists between the rate of migration and the fish's proximity to the White River (Figure 37). In addition, there was a direct relationship between the rate of migration and the discharge

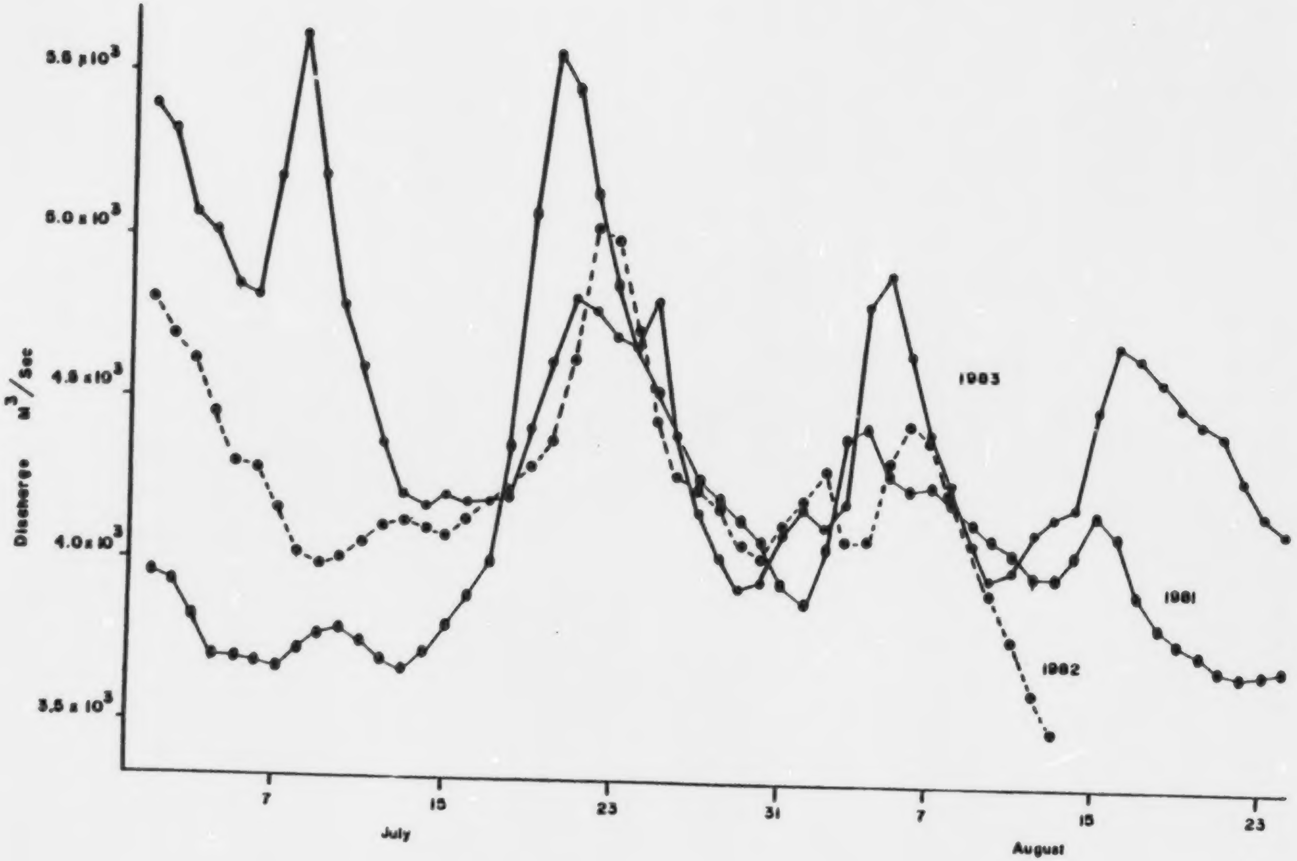

Figure 35 Yukon River discharge at Dawson City, 1981 - 1983.

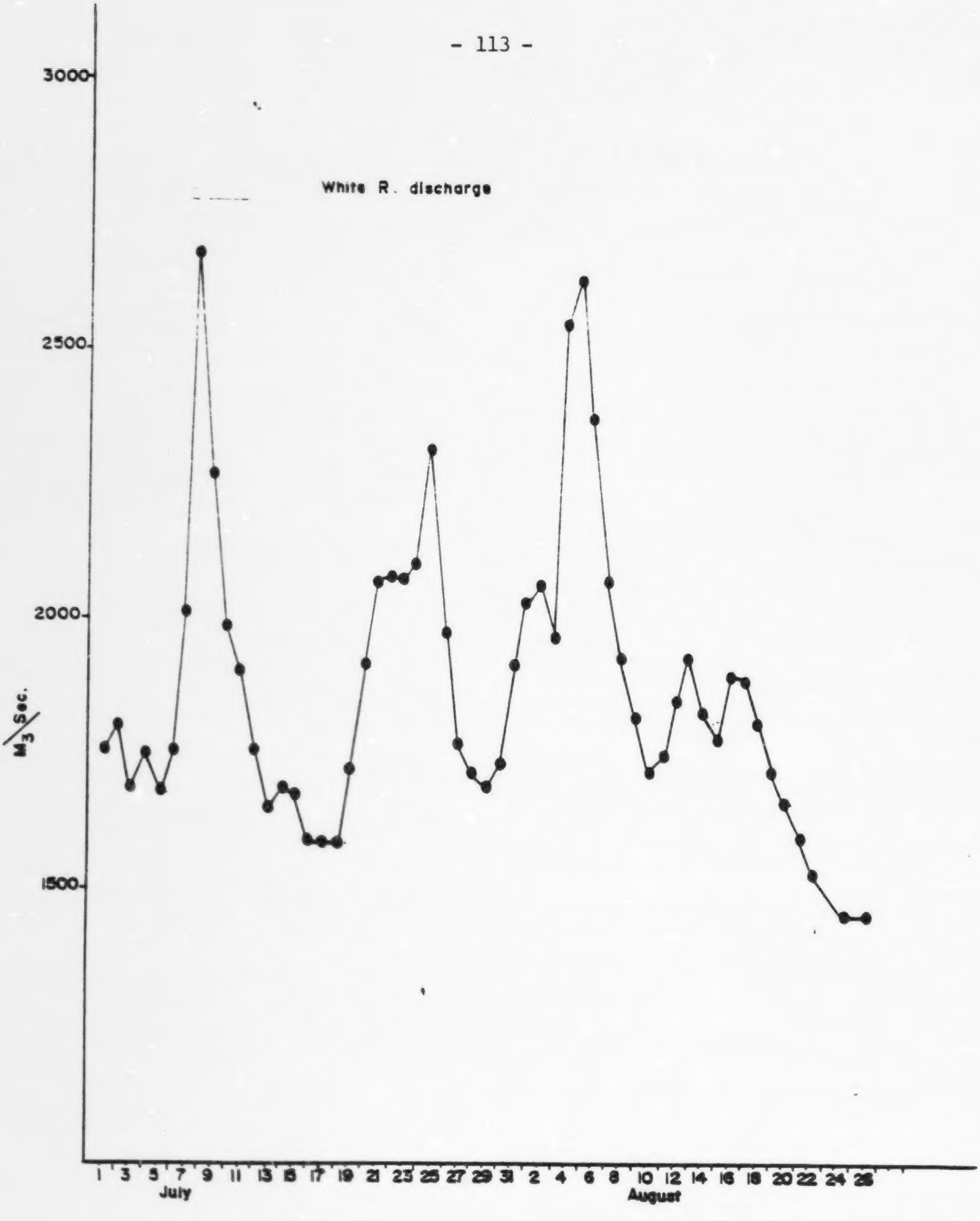

Figure 36 White River discharge July and August, 1983. The White River discharge was calculated as follows: (White River discharge = discharge of Yukon River at Dawson City - Stewart River discharge - discharge of mainstem Yukon above Stewart-Yukon confluence).

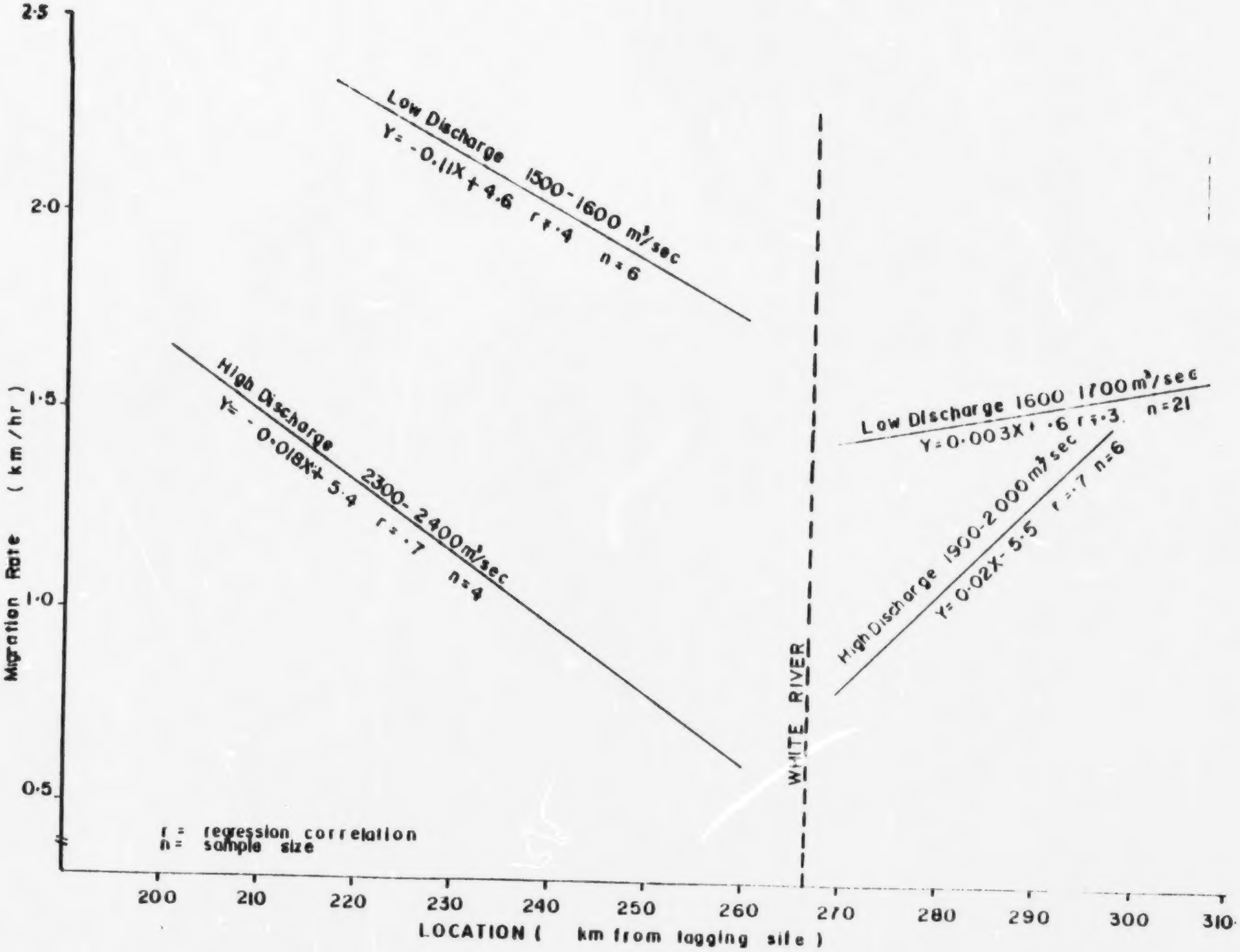

Figure 37 Relationship between discharge levels and migration rates below and above the White River.

level. The lowest migratory rates, for example, were recorded at peak discharge (2,300-2,400 $m^3.s^{-1}$). The slope of the regression line became positive as fish moved above the Yukon-White confluence (Figure 37). The regression coefficient for this line was weak ($r = .14$), however, this was attributed to the use of observatons from a range of discharge levels (1,600-2,600 $m^3.s^{-1}$).

A relationship between discharge levels and commercial catches was often noted by commercial fishermen who indicated that their highest catches were usually made during high or low water levels. This observation was confirmed by the commercial fishery (Dawson City area), where peak chinook catches were recorded at both peak and low discharge levels (Figure 38). There also appeared to be a direct relationship between discharge levels and the chinook catches made at the lower fishwheel. In 1983, peak fishwheel catches occurred during rising or peak discharge levels (Figure 39).

3.2.4 Biological Sampling

The chinook salmon collected for radio-tagging included 81 males (62.3%) and 49 females (37.7%). For males, the mean fork length was 815.0 mm and the range was 600.0 mm to 1,070.0 mm. The mean fork length of females was 871.0 mm, with a range of 750.0 mm to 1,000.0 mm.

The sub-sample for which ages were determined was not large enough for valid comparisons; however, radio-tagged chinook were randomly selected from the fishwheels used for spaghetti tagging, and the age composition for radio-tagged chinook should be similar to that presented in Table 6 (section 2.2.5) for spaghetti-tagged chinook.

3.2.5 Downstream Migrants

Thirteen (10%) of the radio-tagged chinook moved downstream after tag implantation and did not resume their upstream migration (Figure 40). With the exception of one fish, all downstream migrants were tagged shortly after peak flow periods. The gut tissue of fish number 109 was thought to have ruptured during tag implantation. This fish was recaptured at Eagle, Alaska, approximately 18 km

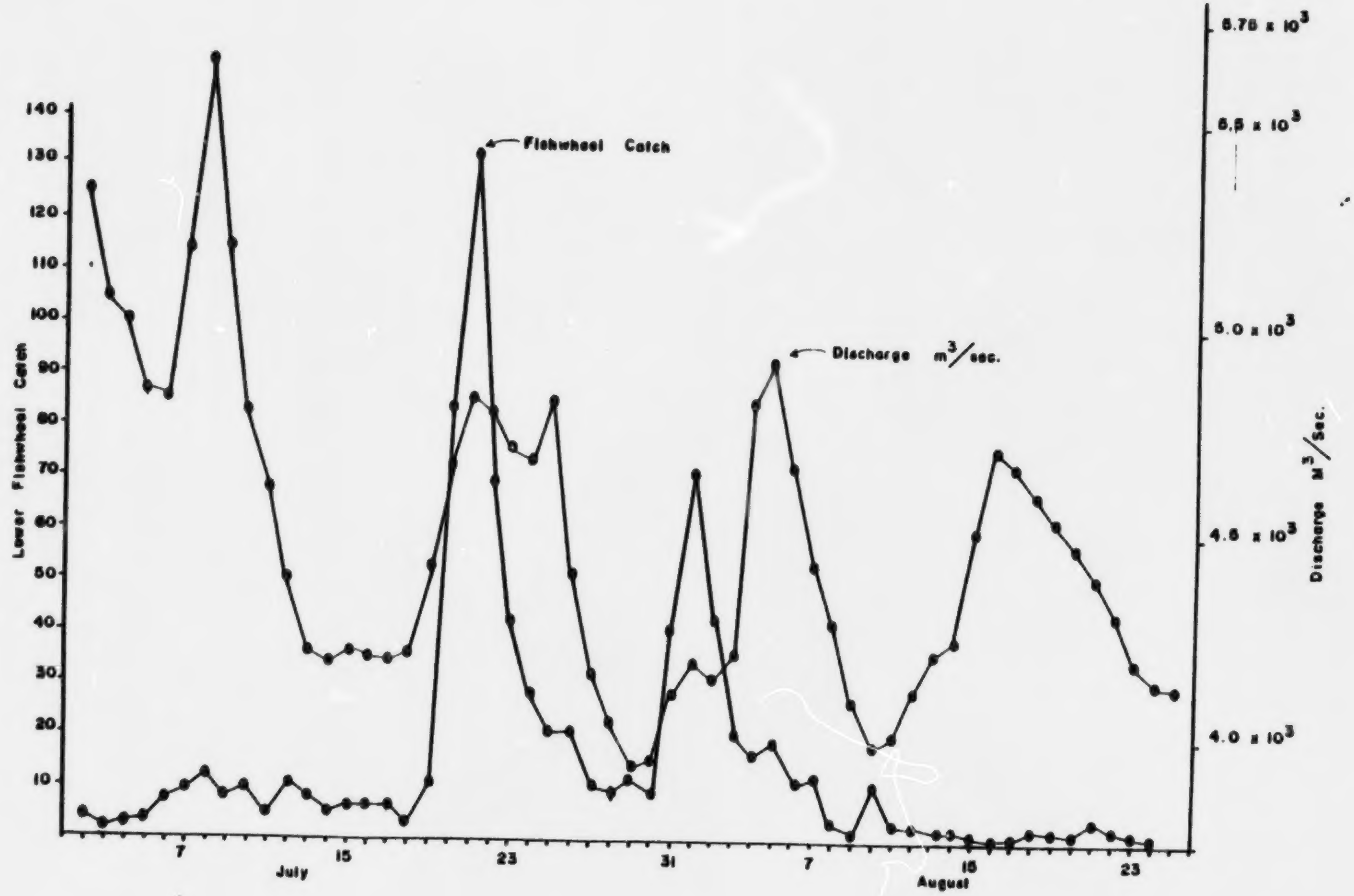

Figure 38 Chinook catch in commercial fishery in relation to Yukon River discharge at Dawson City.

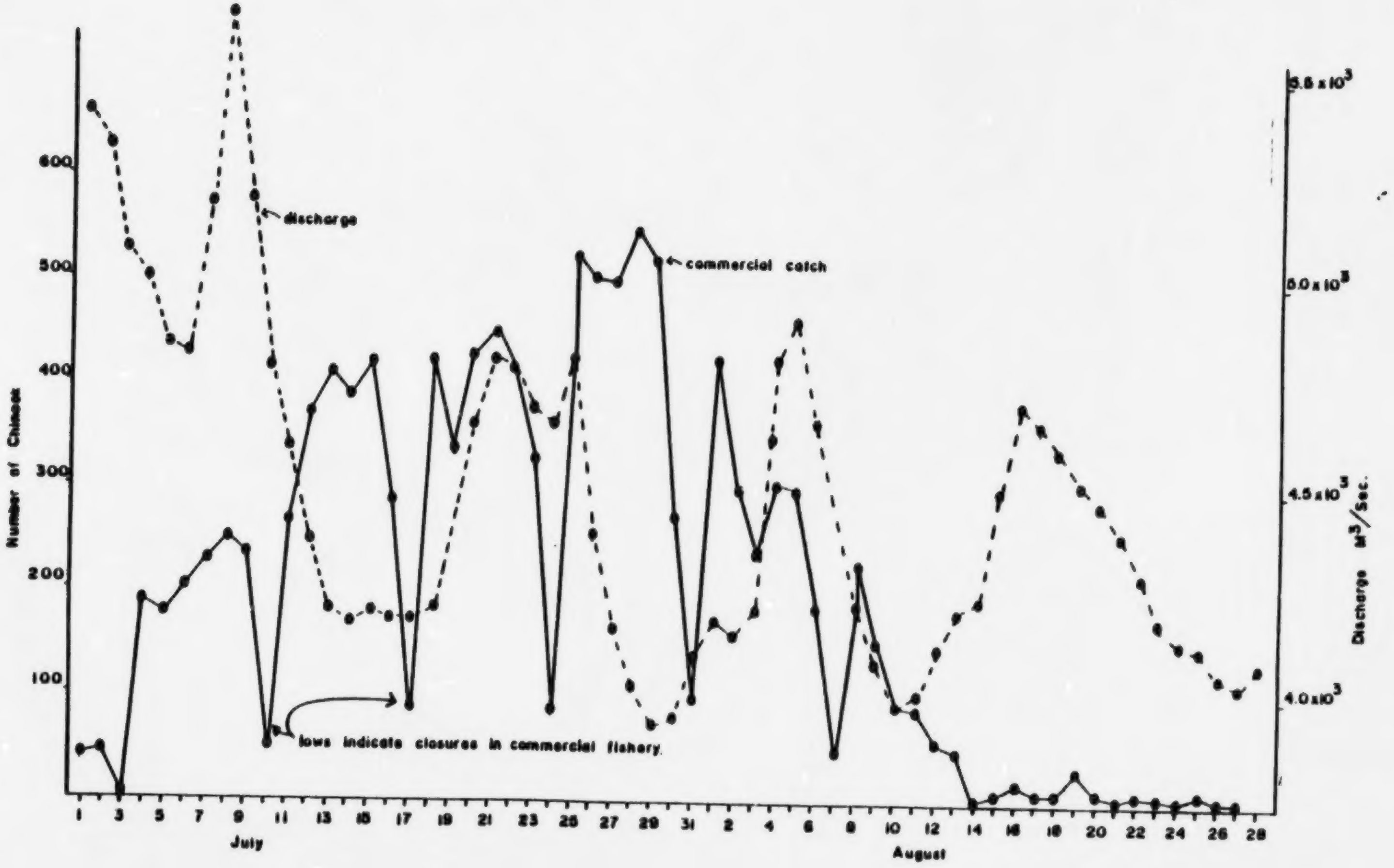

Figure 39 Chinook catch at the lower fishwheel in relation to Yukon River discharge at Dawson City.

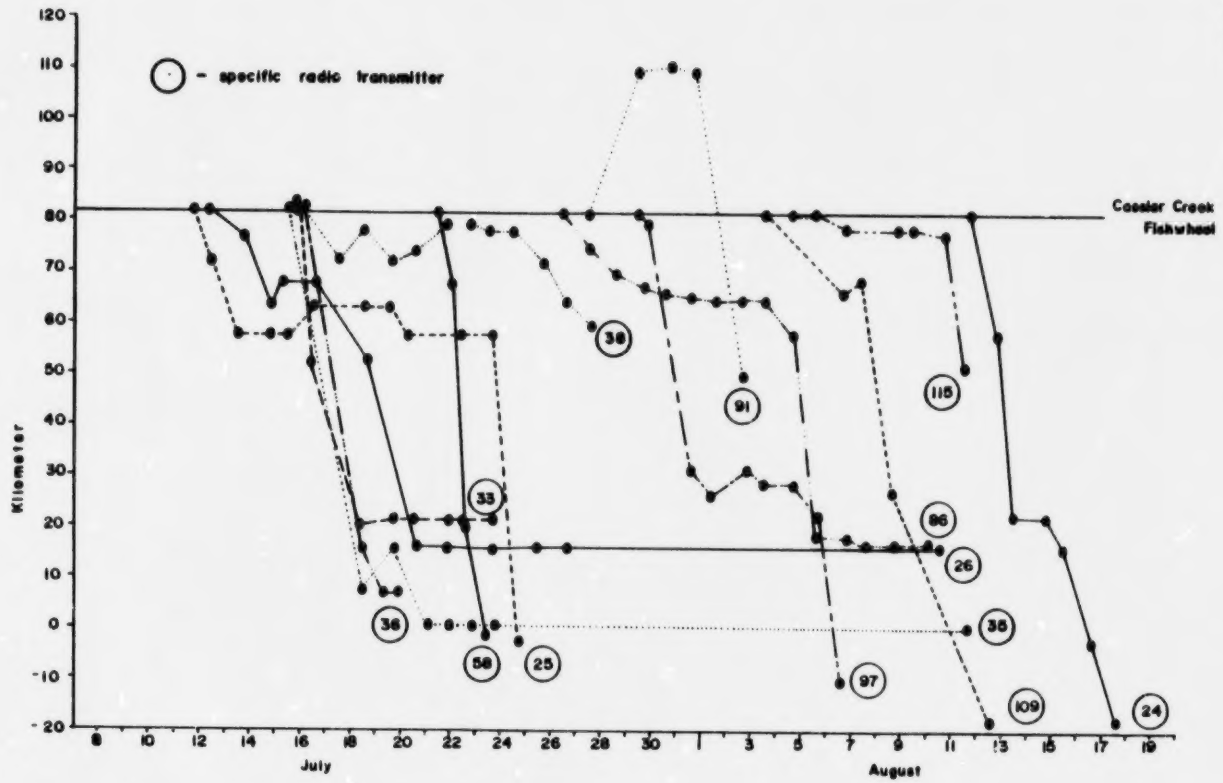

Figure 40 Downstream movements of radio-tagged chinook 1983. Kilometer 0 is the location of the lowest tagging site.

downstream of the tagging site. The largest number of downstream movements (six fish) occurred between July 11 and July 15. Peak river discharge occurred approximately one week prior to this on July 8. Peak flow during this period was largely the result of discharge from the White sub-basin. The Yukon River below the Yukon-White confluence had very high levels of suspended solids, although no quantifiable measurements were taken.

Two additional fish drifted downstream and were recaptured. One fish (number 96) moved from km 81, where it was tagged, to km 68 uring the first 11 hours after its release. For the next two days it was located at km 44, and on the third day it was caught at Cliff Creek (km). Another fish (number 22) moved 24 km downstream after tag implantation, and then moved up the Fortymile River where it remained for 13 days (Figure 41). It subsequently moved downstream to the Yukon-Fortymile confluence, remained there for four days, and was recaptured two days later during upstream migration. Some downstream migrants could have resumed upstream migration and moved undetected through the fishery.

Downstream movements of tagged fish were frequently observed in other tagging studies. Twenty-one percent of the 24 chinook salmon radio-tagged below the Whitehorse Rapids dam in 1979 were thought to have moved downstream (Cleugh and Russell 1980). Sockeye and coho salmon tagged on the lower Taku and Stikine Rivers with spaghetti and Petersen disc tags were frequently recaptured in ocean fisheries (Milligan and Johnston 1982; Milligan 1982). A high rate of ocean recaptures of sockeye tagged with spaghetti-tags on the Taku River in 1983 was apparently associated with handling and confinement (MacKenzie, personal communication).

Downstream movements, which were assumed to be atypical behaviour, were common to a variety of tagging techniques and they appeared to result from a number of factors, including environmental conditions, confinement in holding pens, migratory delay, and tagging. Downstream movements had important implications with respect to tag-recovery studies used to calculate population estimates.

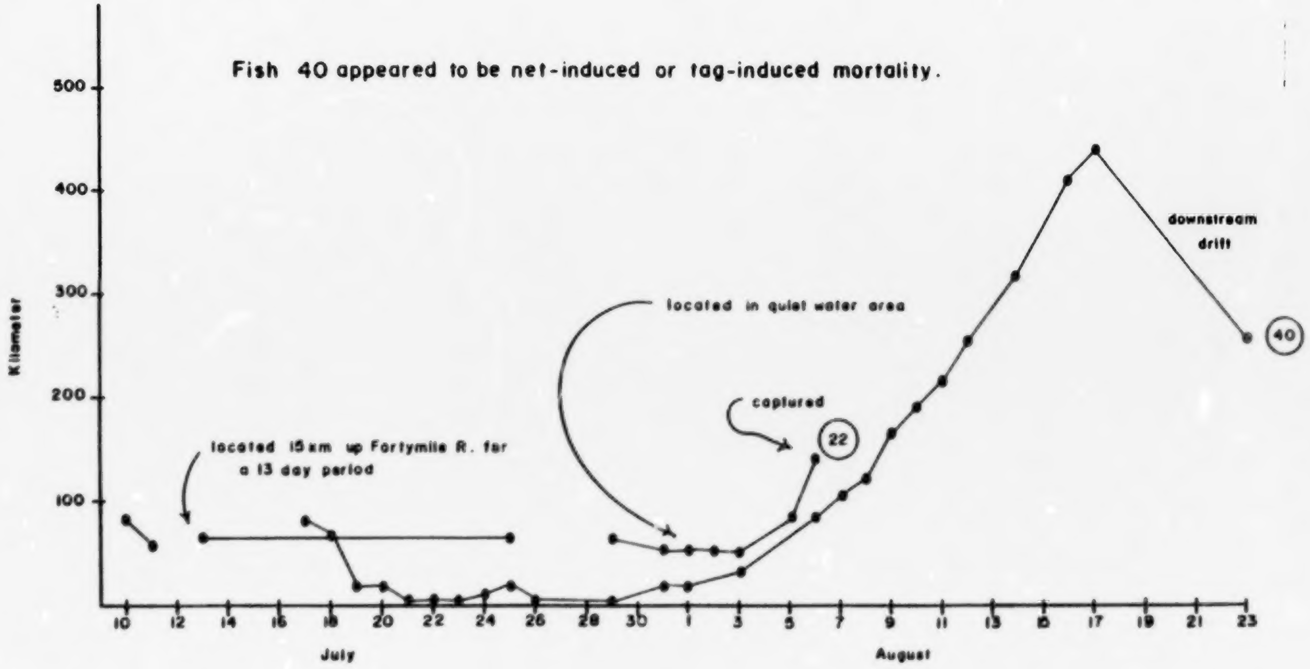

Figure 41 Radio tracking records of two chinook that exhibited migratory delay, 1983. Distances shown are from the lowest tagging site.

3.2.6 Recaptures in Upriver Fisheries

Thirteen (10%) of the radio-tagged chinook were recaptured in commercial and subsistence fisheries above the Stewart-Yukon confluence (Figure 42). Three were caught in the Pelly River, one in the Stewart River, and nine in locations along the Yukon River mainstem. Three of the mainstem recaptures were taken below the Pelly River in commercial gillnets, four were taken in the native fishery at Carmacks, and two were caught by native nets at the plumes of Tatchun Creek and Takhini River. The two chinook caught at the tributary plumes were assumed to be bound for spawning sites within those systems. The exact spawning destinations of the other 11 fish remain unknown because of the many prospective spawning locations that exist above the locations where these fish were recaptured.

3.2.7 Suspected Mortalities and Regurgitations

Eighteen (24%) of the radio-tagged chinook were classified as mortalities or regurgitations. Mortalities were defined as fish that stopped their upstream movements in areas where spawning was not confirmed or suspected. It was not possible to distinguish the cause of the suspected mortalities without directly examining the fish. Mortalities could have resulted from a number of factors, including the following:

- injuries from gillnet encounters (net dropouts)
- tag-induced injuries
- migratory delay associated with tagging.

The tracking records of seven fish are presented in Figure 43. Fish number 117 and number 120 exhibited typical migratory patterns before suddenly stopping their upstream migration. Fish number 116, which exhibited a similar pattern, was recovered and examined. It died from internal hemorrehaging that resulted when the transmitter slipped through the gut lining. Fish numbers 85 and 98 ceased upstream migration immediately below gillnet sites. Fish number 44 initially stopped for 24 hours below a gillnet site, resumed its upstream migration, and stopped farther upriver. Migratory delay appeared to be the cause of death of

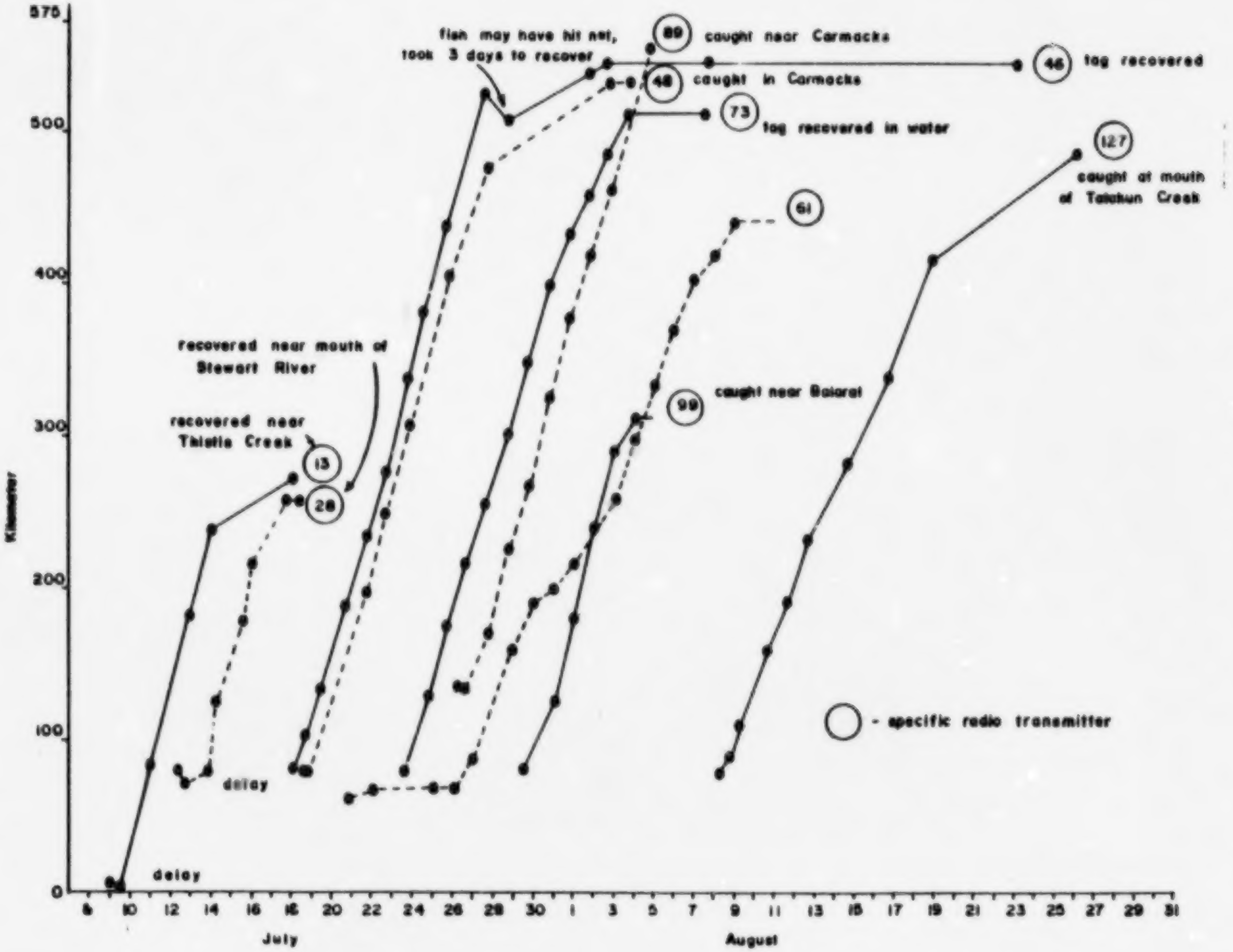

Figure 42 Radio tracking records of chinook captured in locations along the Yukon River, 1983. Distances shown are from the lowest tagging site.

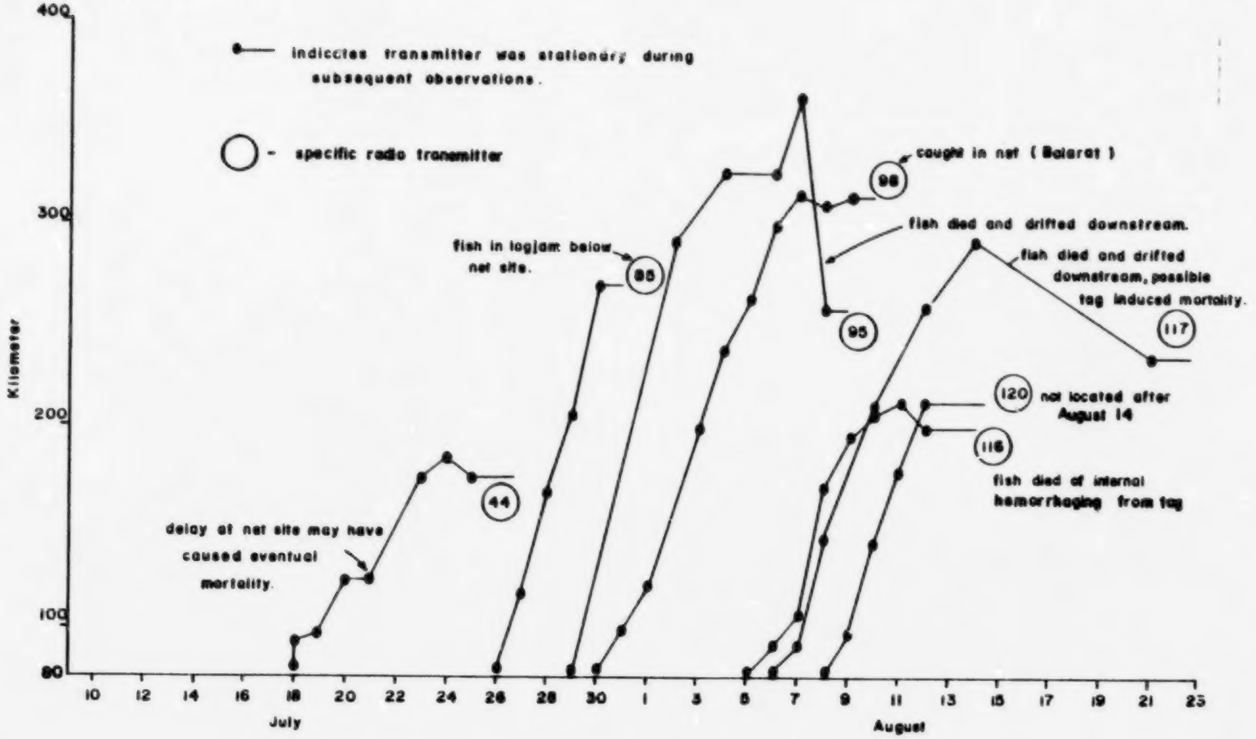

Figure 43 Radio tracking records of suspected net-induced or tag-induced mortalities, 1983. Distances shown are from the lowest tagging site.

fish number 40 (Figure 41), which drifted 80 km below the tagging site over a five-day period before resuming its upstream movement. It moved 20 km upstream in three days, but dropped downriver again as water levels rose. It then resumed its upstream movement, passed the tagging site 21 days after it was tagged, and migrated upriver to km 440 where it stopped and drifted downstream.

Regurgitations were defined as those radio-tagged fish that remained sedentary at or near the tagging site. Regurgitations were thought to be most probable at the tagging site and not farther upriver. The transmitter of fish number 113 was regurgitated at the tagging site.

As mentioned above, it was not usually possible to distinguish between net-induced and tag-induced mortalities. Net dropouts or tag-induced mortalities may be more apparent with fish equipped with radio transmitters because the fish movements are continually monitored. Net dropouts can result in high non-catch mortalities. Ricker (1976) estimated that one immature fish is killed for each one landed in a high-seas gillnet fishery. For mature fish in their final year, one dies for every three landed. Similarly, salmon undertaking freshwater migrations may be subjected to significant non-catch mortalities in river fisheries. Yukon River chinook undertake an extensive non-feeding migration before entering Canada. The physiological demand of this migration could increase their susceptibility to capture by reducing net avoidance capability, and it could contribute to high mortalities for net dropouts.

4.0 DISCUSSIONS AND RECOMMENDATIONS

4.1 Review of Tagging Techniques

Two types of tagging techniques were used in this study. Spaghetti tags were applied to determine quantitative information which included population estimates and exploitation rates. Radio transmitters were applied to determine more qualitative informaton such as migratory behaviour, stock separation, and the location of discrete spawning areas. Information from spaghetti tagging is dependent upon the subsequent recapture of the fish whereas radio-tagging provides continuous information after the tag is applied. The radio tracker essentially becomes a passive observer and recorder of the fish movements. A summary of the major differences in the tagging techniques appears in Appendix 9.

There are a number of requirements or conditions of mark-recapture studies which are applicable to the spaghetti-tagging program. These conditions include the following (cited from Ricker 1975):

1. The marked fish suffer the same natural mortality as the unmarked.

2. The marked fish are as vulnerable to the fishing being carried on as the unmarked ones.

3. The marked fish do not lose their mark.

4. The marked fish become randomly mixed with the unmarked, or the distribution of the fishing effort (in subsequent sampling) is proportional to the number of fish present in different parts of the body of water.

5. All marks are recognized and reported upon recovery.

In general, the chinook spaghetti-tagging program fulfilled the preceding requirements. The age composition of the tagged chinook was almost identical to that in the tag recovery sample, although the selectivity of the commercial fishery gillnets altered the size and sex composition of chinook caught in the commercial fishery. The tagged fish appeared to retain their tags and mix randomly with the untagged fish. Several tags were observed and/or recovered in spawning areas.

The number of chinook in the tagged sample appeared to be representative of run strength in both 1982 and 1983, however, the sample size was small in 1982. Tag returns were received from commercial, native subsistence, domestic, and sports fishermen.

The conditions or requirements of a mark-recapture study most difficult to assess in this study were:

A. the vulnerability of tagged fish to recapture;

B. the natural mortality of tagged fish;

C. the reporting of all recaptured tags.

Conditions A and B involve the behavioural and physiological effects of tagging (Appendix 10). Little is known about these effects because they are difficult to study under field conditions. Apart from the radio-tagging portion of the study, no attempt was made to study the effects of tagging on Yukon River chinook salmon. It is difficult to compare radio-tagging with spaghetti-tagging in terms of conditions A and B because they involve different techniques; however, behavioural responses resulting from radio-tagging may be similar to those resulting from spaghetti-tagging (Appendix 10). As noted previously, Yukon River chinook migrate approximately 1,900 km in freshwater prior to reaching the tagging site(s) and must migrate an additional 200 to 1,200 km to reach spawning destinations. The physiological demand of this non-feeding migration must be critical to spawning success. Chinook migration is influenced to an undetermined extent by environmental conditions and disease factors. Migration occurs during the summer months when water temperature and velocity are at peak levels. Higher water temperatures, for example, facilitate the growth of bacterial and fungal diseases. The additional stress created by live-capture, confinement, and tagging could increase the vulnerability of chinook to recapture.

Marked fish could potentially suffer greater mortality than unmarked fish because of disorientation and stress which could result from confinement, handling, and tagging. For similar reasons, marked fish may not be randomly distributed. It is important to note that tagging procedures have been known to cause erratic movements in fish for days or even weeks (Ricker 1975). These movements were apparent with radio-tagged chinook that exhibited downstream or delayed migration (see section 3.2.5). As a result of certain tagged fish being unavailable for recapture, the population could be overestimated. Conversely, as a result of tagged fish being recaptured at a higher rate than untagged fish, the population could be underestimated.

Some captures of tagged fish may have gone unreported. Reasons for this would include the indifference of some fishermen to the tagging program, and fear on the part of some fishermen that a large number of tag returns could result in fishing restrictions. As a result of unreported tags, the population estimates could be overestimated.

The use of an improved tag type and reduced confinement and handling would result in a more efficient tagging procedure, subjecting the salmon to less physiological stress. The following recommendations should be considered for future tag-recovery programs:

1. Confinement in the holding pens should be restricted to a minimum holding period of approximately two hours. This would require additional field personnel and 24-hour tagging.

2. Tag application should occur while the fish is in the water. Tagging could occur in a more specialized holding pen designed solely for this purpose.

3. The development and use of another tag type should be considered.

4.2 Spawning Areas and Sub-basin Production

Sixty-five chinook spawning areas within Canadian portions of the Yukon River drainage (Figure 44) were identified by previous studies (Walker 1976; Ennis et al. 1982; DFO files). Sixty-one spawning areas are located in the upper Yukon River Basin, while the remaining four areas are in the Porcupine sub-basin.

The spawning areas are distributed throughout all major headwater tributaries, usually in association with lake-fed systems. Several discrete mainstem spawning areas are known to exist in addition to these 65 tributary spawning areas. Seven principal mainstem spawning areas were identified along the mainstem Yukon River (Walker 1976; section 2.2.6 herein), and approximately 10 discrete mainstem spawning areas are located on the Teslin River (Ennis et al. 1982).

The number of new spawning areas identified in this study was lower than originally anticipated. It is likely that most of spawning sites supporting 100 or more chinook have been identified. Undocumented spawning areas probably occur along the mainstem Yukon and in the more remote portions of some tributaries.

As a general rule, good quantitative data on chinook returns to documented spawning areas do not exist. Consistent annual escapement surveys have not been conducted by the Department of Fisheries and Oceans nor have they been equally apportioned to the various sub-basins. The high survey costs and the remoteness of many spawning areas have limited annual escapement surveys. In addition, the accuracy of the survey information available has been limited by a number of factors, including water depth and clarity, the timing of the surveys, and the ability of the observers. Aerial survey counts have not usually been corroborated by weir counts or other techniques that cover the duration of the spawning period. A number of areas such as the Big Salmon, Nisutlin and Wolf Rivers annually support large spawning populations which have been clearly visible because of the favourable water conditions. Mainstem spawning areas, on the other hand, appear to support large spawning populations, but it has not been possible to quantify the number of fish returning to these areas.

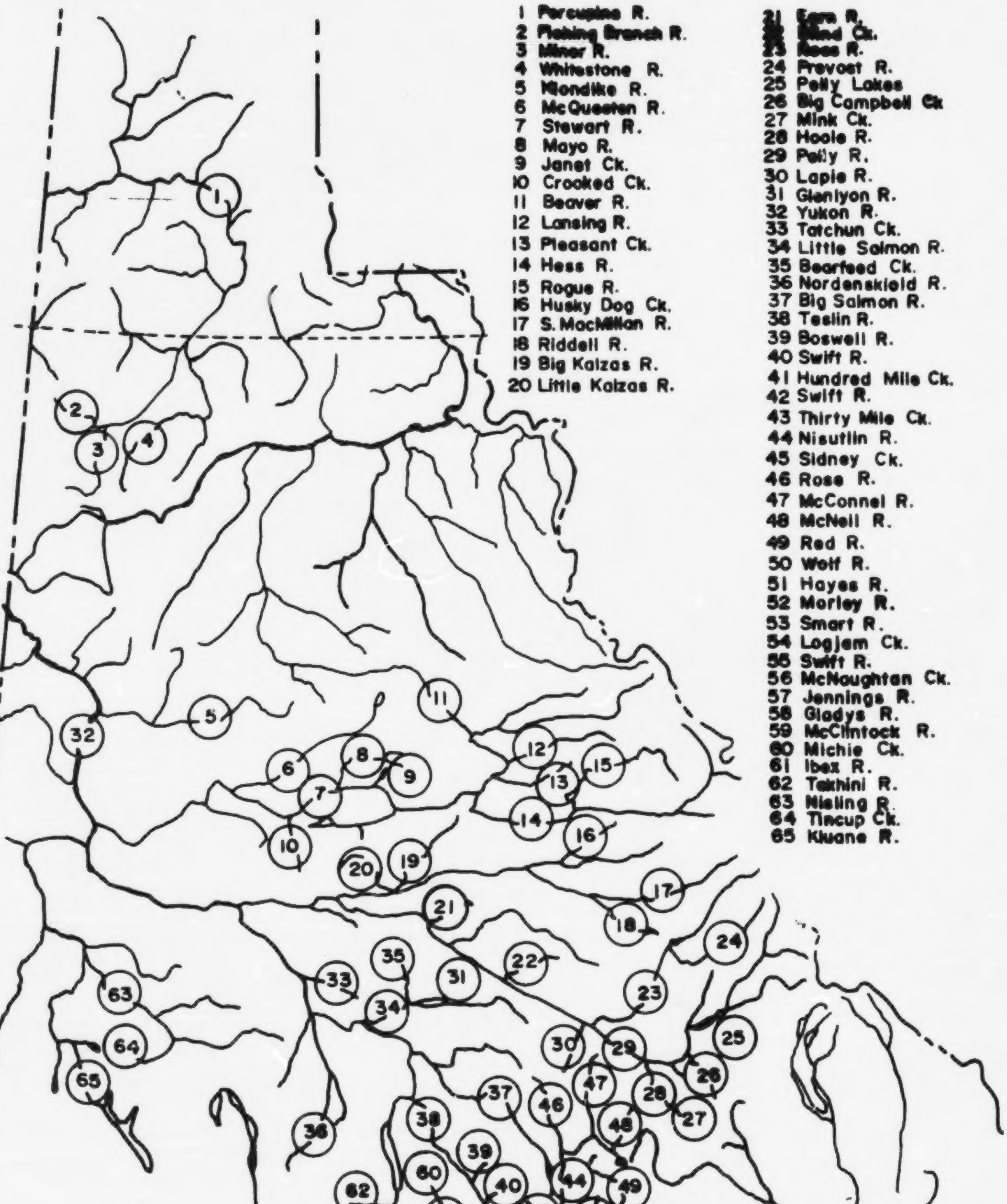
1 Porcupine R.
2 Fishing Branch R.
3 Miner R.
4 Whitestone R.
5 Klondike R.
6 McQuesten R.
7 Stewart R.
8 Mayo R.
9 Janet Ck.
10 Crooked Ck.
11 Beaver R.
12 Lansing R.
13 Pleasant Ck.
14 Hess R.
15 Rogue R.
16 Husky Dog Ck.
17 S. MacMillan R.
18 Riddell R.
19 Big Kalzas R.
20 Little Kalzas R.
21 Earn R.
22 Blind Ck.
23 Ross R.
24 Prevost R.
25 Pelly Lakes
26 Big Campbell Ck
27 Mink Ck.
28 Hoole R.
29 Pelly R.
30 Lapie R.
31 Glenlyon R.
32 Yukon R.
33 Tatchun Ck.
34 Little Salmon R.
35 Bearfeed Ck.
36 Nordenskiold R.
37 Big Salmon R.
38 Teslin R.
39 Boswell R.
40 Swift R.
41 Hundred Mile Ck.
42 Swift R.
43 Thirty Mile Ck.
44 Nisutlin R.
45 Sidney Ck.
46 Rose R.
47 McConnel R.
48 McNeil R.
49 Red R.
50 Wolf R.
51 Hayes R.
52 Morley R.
53 Smart R.
54 Logjam Ck.
55 Swift R.
56 McNaughtan Ck.
57 Jennings R.
58 Gladys R.
59 McClintock R.
60 Michie Ck.
61 Ibex R.
62 Takhini R.
63 Nisling R.
64 Tincup Ck.
65 Kluane R.

Figure 44 Chinook spawning areas in the Yukon River basin in Canada. Spawning areas 1 to 4 are located within the Porcupine sub-basin.

A large number of the chinook spawning areas presented in Figure 44 support limited returns of only 100-300 chinook. Information from this study suggests that most spawning areas are underutilized at the present time. Many of the existing chinook populations appear to persist as remnants of larger historic returns.

The sub-basins of the upper Yukon River drainage ranked in order of chinook production are as follows:

1. Mid-Yukon mainstem* (Stewart-Yukon confluence to Hootalinqua). This area includes the Big Salmon, Little Salmon, and Nordenskiold Rivers, and Tatchun Creek;
2. Teslin;
3. Pelly;
4. Stewart;
5. Upper Yukon mainstem* (upstream of Hootalinqua), including the Takhini River;
6. White;
7. Lower Yukon mainstem* (downstream of Stewart-Yukon confluence), including the Klondike River.

This ranking is tentative because the information regarding chinook abundance in specific tributaries is somewhat limited, and because the study was confined to a two-year period. The importance of a particular sub-basin could vary annually. The full potential of each sub-basin was not obvious in this study because spawning escapements were below average in both study years. The productive capacity of the various sub-basins should ideally be studied over a full chinook life cycle (seven-year period). Another important consideration with respect to the productive capacity of the sub-basins is the enhancement potential of sub-basin tributaries. Preliminary enhancement techniques (i.e. increasing escapement levels) could alter the ranking of sub-basin productivity.

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* As noted previously in sections 1.2 and 3.2.2.1, for comparative purposes, the mainstem Yukon River was divided into three components: the lower, middle, and upper Yukon.

4.3 Habitat Utilization

Chinook spawning areas involve a variety of habitat types. Generalizations that apply to key salmonid habitat requirements are applicable to Yukon chinook salmon. Spawning habitat should include the following:

- a suitable gravel substrate;
- a sustained water flow that is well oxygenated;
- a suitable thermal regine;
- suitable rearing habitat for juvenile chinook.

In the following discussion, the distribution of chinook salmon within the study area is related to a number of key habitat characteristics. The results of mainstem spawning habitat surveys were discussed in section 2.2.6. Spawning was most concentrated below riffle areas. Water depth was variable and current flow in the side-channel areas where spawning occurred was moderate relative to that of the main river channel. Chinook spawning in areas other than mainstem habitat involves a variety of habitat types that include both small and large tributaries, and the outlets of lakes. A strong relationship exists between chinook spawning sites and lake-fed tributaries, which are prevalent in the south-central portions of the Yukon River Basin. Chinook have historically spawned at the outlets of the majority of the lakes within the study area (Appendix 11). The habitat characteristics of lake outlet areas have not been technically investigated, however, the following characteristics are common to these areas:

1. A constant flow regime is maintained in lake outlet areas throughout the winter months. The probability of flood scouring, dessication, and freezing of redds, is less in outlet areas than in habitat that is subject to greater environmental extremes.

2. Lake outlets may involve warmer water temperatures. These areas are the first to become ice-free in the spring and some may remain ice-free throughout the winter months. The mechanism that causes the warmer water temperatures could relate to a number of factors which include: the temperature profile (density) of water in lakes during the winter months, the shape and slope of the lake basin near the outlet, and possibly a mixing effect which could result in upwelling water.

3. The selection of lake outlet areas may involve a provision for juvenile rearing. An abundant supply of phytoplankton and zooplankton may be available to chinook fry emerging in these areas. Since outlet areas open in advance of other areas, photosynthetic activity may commence earlier in the year.

4. Lake outlet areas are usually free of suspended solids. Spawning below lake outlets, therefore, can occur in tributaries that otherwise have poor spawning habitat caused by high levels of suspended solids. Chinook can ascend tributaries with high levels of suspended solids to spawn in areas of clear water below lake outlets.

Another important habitat requirement of chinook salmon involves freshwater rearing. Following the incubation period, the rearing period is believed to be the most critical portion of the salmonid life cycle. Chinook fry in the upper Yukon River Basin usually rear for one to two years in freshwater prior to their seaward migration. Fry inhabit a variety of small and larger tributaries throughout the summer months, but return to larger tributaries for overwintering (Walker 1976). The availability of overwintering habitat and the physiological demands of the overwintering period could be the most important factors limiting chinook production within Canadian portions of the Yukon River drainage.

4.4 Canadian Contribution to Total Yukon Drainage Chinook Production

All five sub-basins within the study area are important producers of chinook salmon; however, the contribution of these areas to the overall production for the entire Yukon drainage is unknown. An estimate of the importance of Canadian chinook-producing areas relative to those in Alaskan portions of the Yukon River drainage can be determined using catch and escapement information. In the following discussion some preliminary estimates are determined.

The lowest and highest chinook catches recorded in the 1972-1981 period (combined Alaskan and Canadian commercial and subsistence catches) were 82,785 (1975) and 222,812 (1980) chinook, respectively (Table 20). These catches are assumed to represent the low and high cycle year returns respectively. Exploitation rates of 40, 50, 60 and 70% were applied to these catches to determine a range for the total in-river stock (Table 20). Based on these exploitation rates, the total in-river stock ranged from 118,000 to 207,000 chinook for the lowest recorded catch and from 318,000 to 557,000 chinook for the highest recorded catch. The number of females and the total escapement required to produce the in-river stocks were determined from the assumptions outlined in Table 20. The overall exploitation rate on Yukon chinook salmon is thought to approach and possibly exceed 60-70%. On the basis of exploitation rates in the 60-70% range, a spawning escapement of 39,000 to 46,000 chinook would be required to produce the lowest return while a spawning escapement of 106,000 to 124,000 chinook would be required to produce the highest return.

The spawning escapement into the Canadian sections of the Yukon River basin within the study area ranged from approximately 20,000 in 1982 to 31,000 in 1983. Both tagging programs were conducted during years with average to below average returns. The 1982 aerial escapement counts, for example, were approximately one-third of the 1981 counts. Other escapement information suggests that escapement could approach 60,000 chinook during a peak cycle year return. Based on a minimum escapement of 20,000, a low cycle year, and exploitation rates from 60-70%, the total Canadian chinook production (excluding the Porcupine sub-basin) would range from 44-51% of the total producton. Similarly, based on an escapement of 60,000, a peak cycle year, and the same exploitation rate, the total Canadian chinook production would range from 48-57%. As stated earlier, these estimates are preliminary, but they demonstrate that chinook production within Canadian section of the Yukon River Basin is in the order of magnitude of 50% of the total Yukon River Basin production.

TABLE 20 Escapement required to produce lowest and highest Yukon chinook harvests (1972-1981) at exploitation rates between 40% and 60%

	EXAMPLE LOWEST RECORDED CHINOOK CATCH 1972 - 1981 82,785 - 1975				EXAMPLE HIGHEST RECORDED CHINOOK CATCH 1972 - 1981 222,812 - 1980			
	40%	50%	60%	70%	40%	50%	60%	70%
Total In-River Stock at Exploitation Rate.	206,962	165,570	137,975	118,393	557,030	445,624	371,353	318,303
Number of Females req'd to produce total stock at return of 6 adults/female spawner	34,493	27,595	22,996	19,737	92,838	74,271	61,892	53,050
Total Escapement req'd to produce total stock at ratio of 1 male: 1 female	68,987	55,190	45,992	39,464	185,676	148,541	123,784	106,101

Assumptions:

1. Six adults return/ female spawner.
2. A male:female ratio of 1:1 occurs in escapement stocks.
3. The low and high catches correspond with low and high cycle year returns.

4.5 Overview of Chinook Resource

General information on the chinook salmon resource was summarized in section 1.2. The naturally occurring chinook salmon stocks, produced in approximately 55 Canadian and 56 Alaskan streams within the Yukon River drainage, have not received any enhancement effort. The first work proposed for the stocks involves introducing hatchery-reared fry into the upper Yukon drainage above the Whitehorse Rapids Dam (possibly in 1985) to offset juvenile losses at this facility.

The exploitation of Yukon chinook salmon is atypical in that they are the direct target of commercial fisheries in Alaska and Canada. In other Pacific coast gillnet fisheries, chinook salmon are usually harvested as an incidental catch. This has resulted from restrictive measures designed to protect and/or rebuild depressed stock levels. The majority of naturally occurring chinook stocks along the Pacific coast are experiencing severe conservation problems that have resulted primarily from over-exploitation and habitat loss.

The current status of Yukon drainage chinook stocks is largely unknown. Chinook population estimates, escapement counts and catch statistics are available, but there is a lack of comparative historical information. Record chinook catches (combined Alaskan and Canadian fisheries) were recorded between 1979 and 1983 (Table 3). The catches made between 1979 and 1981 correspond with high escapement counts, thus it is unlikely that these catches were made at the expense of spawning escapements. This was not the case in 1982 and 1983, particularly within Canadian portions of the drainage. Catch levels remained high, but spawning escapements were lower than those observed in the 1979-1981 period. The magnitude of the chinook return to Canadian spawning areas appears to have declined substantially from historic levels. This observation is based on the large number of documented spawning areas which support low spawning returns (100-300 chinook) relative to available habitat. Many of these populations may persist as remnants of larger historic returns.

Chinook migration within the Yukon River involves a number of "mixed stocks" bound for a wide range of spawning destinations. Canadian-bound chinook are harvested throughout the entire length of the Yukon River, at locations that can be measured in days, as well as in hundreds or even thousands of kilometers, from the spawning areas. This "mixed stock" type of fishery could result in the over or under-exploitation of some tributary populations relative to their actual abundance (Alaska Department of Fish and Game 1982). The smaller Canadian-bound chinook populations could suffer possible extinction from heavy fishing pressure exerted in Alaskan and/or Canadian portions of Yukon River drainage.

In general, spawning and rearing habitat has not been seriously impaired throughout Canadian portions of the Yukon drainage. Habitat destruction has primarily resulted from hydroelectric facilities and mining activities. Chinook returns to the north fork of the Klondike River (Siegel unpublished) and the Mayo River (Kendel 1973), were virtually eliminated by impassable dams*. Spawning and rearing habitat within a number of the smaller tributaries has probably been negatively influenced by placer mining activities (Mathers et al. 1981). The extent of habitat loss and disruption is poorly understood for most areas since little is known about historic chinook populations. Available information suggests that the historic distribution of chinook salmon within the study area was more extensive than it is today. Although peak spawning escapements were recently observed, available habitat is underutilized. Overfishing is the most obvious explanation for the current status of chinook populations throughout Canadian portions of the Yukon River drainage.

In view of the preceding discussion, Canadian-bound chinook stocks are susceptible to overexploitation in both Alaskan and Canadian river fisheries. They are also vulnerable to excessive harvesting in ocean fisheries, which include the Japanese mothership fishery, and possibly foreign trawl and Alaskan troll fisheries.

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* Klondike River chinook may also have been influenced by heavy fishing pressure and mining activities.

Little is known about the interception of stocks in the latter two fisheries. Since the Yukon is a transboundary river and no salmon interception agreement exists between Canada and the United States, adequate measures have not been implemented for the protection of the Canadian chinook resource. This resource involves natural populations which spawn and rear in virtually unimpaired habitat. Specific measures that are necessary for the status of this renewable resource to be maintained in perpetuity include the following:

1. a salmon interception agreement between Canada and the United States;
2. adequate habitat protection measures;
3. effective fisheries management.

4.6 Recommendations

The recommendations of this report are as follows:

1. The Department of Fisheries and Oceans should initiate joint management and research with the Alaska Department of Fish and Game. A joint committee of representatives of Canadian and United States government agencies having fish resource related mandates could monitor the chinook salmon resource and provide the framework necessary for a management agreement.

2. An annual chinook tag-recovery program should be conducted within the Canadian portion of the Yukon River. This program could provide a consistent data base of population estimates, escapement estimates, and exploitation rates within Canadian waters. improved live-capture techniques should be developed as part of the tagging program in an attempt to offset the selective nature of the fishwheels.

3. The management of the Canadian chinook resource should involve a variable open day fishing schedule which reflects run strength. Emphasis should be placed on maintaining adequate escapement levels. The Canadian commercial fishery appears to be differentially removing specific age classes, particularly

6_2 females. Catch quotas or gear restrictions including mesh restrictions could offset possible overexploitation of specific age classes. Preliminary chinook enhancement work should be initiated through increased escapement levels.

4. A number of biological studies should be initiated. In general terms, these studies involve life history information, enumeration of spawning adults, and management-related studies. The following investigations are recommended.
   a) the feasibility of using hatchery stocks to enhance historic spawning areas and those which may be currently underutilized;

   b) the life history of juvenile chinook. Investigations should include:
      - the survival of overwintering eggs
      - feeding behaviour of fry
      - seasonal migratory movements
      - extent of lake rearing
      - overwintering habitat.

   c) the effect of the turbines at the Whitehorse Rapids Dam during smolt out-migration;

   d) the examination and possible development of technology to enumerate chinook in mainstem spawning areas;

   e) electrophoretic studies, juvenile coded-wire tagging, and scale pattern analysis. These investigations would provide more detailed information on specific stocks and their contribution to various fisheries. Coded-wire tagging would provide information on ocean migrations and foreign interceptions of chinook that originate within Canadian portions of the Yukon River Basin.

5. A number of of spawning areas should be annually monitored as index areas. The use of counting weirs in selected tributaries would provide accurate escapement counts.

6. An annual report on the current status of the chinook resource should be available to the general public and to all commercial, domestic, and subsistence fishermen in the Yukon Territory.

ACKNOWLEDGEMENTS

The length and scope of this program demanded the dedication and perseverance of many people, often under adverse field conditions. Personnel who assisted with the field studies included: Robin Hunka, Mike Herdes, George Cronkite, Tom Cornett, Glen Swaikoski, Gaetan Beaudette, Ray Bryant, Steve Sandiford, Peter Ballantyne, Clive Osborne, Jeanne Beaudoin, Yann Herry, Robert Horseman. Figures were drafted by Robin Hunka. Data were prepared by George Cronkite, Tom Hurds, and Robin Hunka.

Thanks to Torrie Hunter (patrolman), Scotty Roxburgh (Fishery Officer), and Tim Young (Fishery Officer) for the tag returns they collected and the logistic support they gave to the field crew. Special thanks to Don Bergeron of Air North. Additional logistic support was given by Peter Etherton and Ed Ramsey.

Thanks to Robin Harrison (Senior Biologist-Fraser River, Northern British Columbia and Yukon division of DFO) for valuable editorial comments. The manuscript was prepared by Mary Armstrong.

Special thanks to all commercial, subsistence, and domestic fishermen who returned tags and provided valuable information on the chinook salmon resource.

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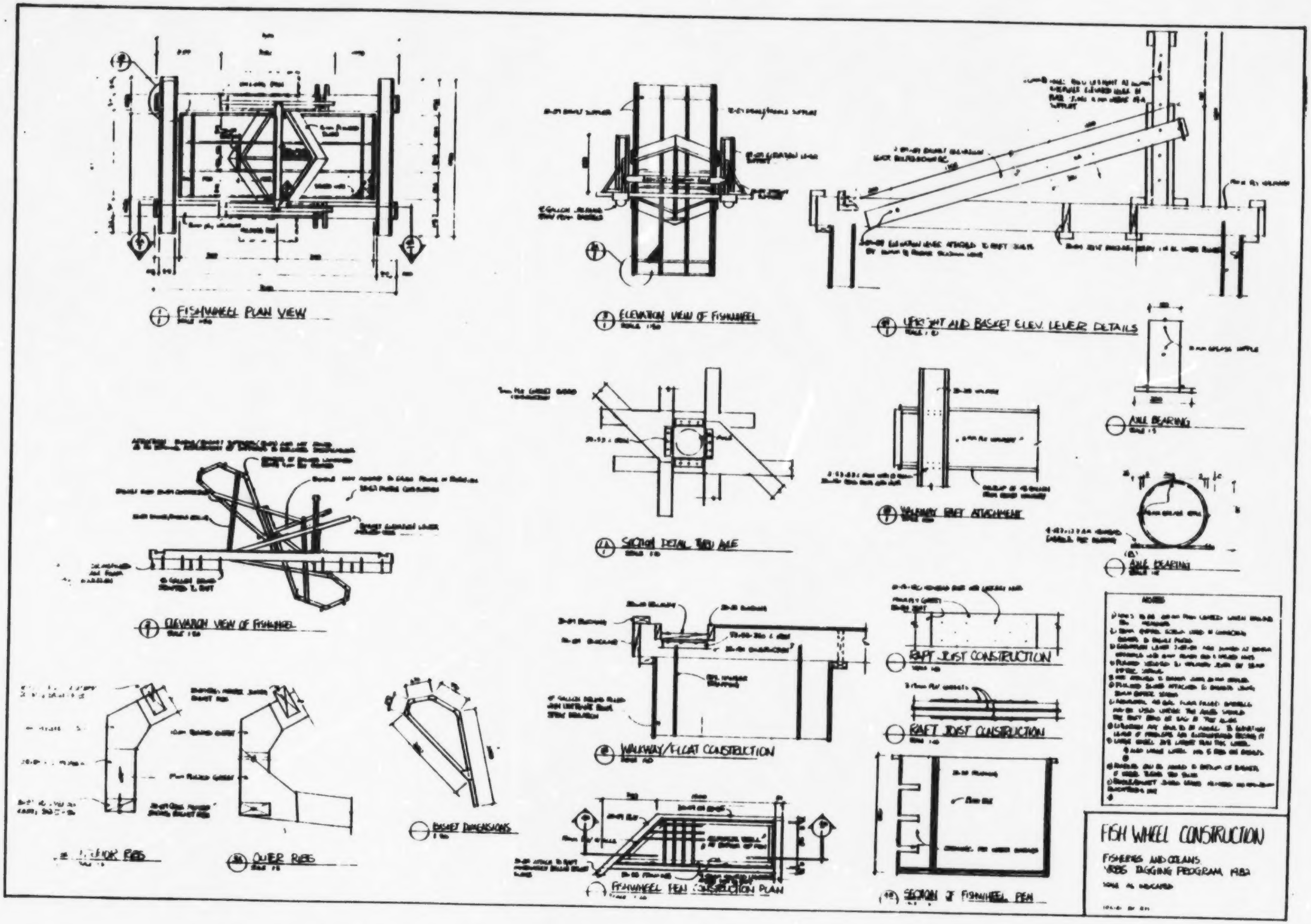
FISHWHEEL PLAN VIEW
ELEVATION VIEW OF FISHWHEEL
UPRIGHT AND BASKET ELEV. LEVER DETAILS
AXLE BEARING
SECTION DETAIL THRU AXLE
WALKWAY RAFT ATTACHMENT
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FISHWHEEL PEN CONSTRUCTION PLAN
SECTION OF FISHWHEEL PEN
FISH WHEEL CONSTRUCTION
FISHERIES AND OCEANS
YRBS TAGGING PROGRAM 1982
SCALE AS INDICATED

Appendix 1   Fishwheel Design

Appendix 2

Incidental species tagged in fishwheels 1982-1983

SPECIES	DATE TAGGED	FORK LENGTH (cm)	AGE	TAG NUMBER
Burbot	27/08/82	35.0	-	09219
	28/09/82	50.0	-	09664
	29/09/82	74.5	-	09706
Inconnu	25/08/82	45.0	-	09217
	26/07/82	30.0	6-1	09090
	28/08/82	-	-	08074
	28/07/83	70.0	-	16714
	10/08/83	51.0		00003
	12/08/83	-	-	00022
	26/08/83	55.0	-	00170
Longnose Sucker	28/08/82	33.0	-	09220
Cisco	26/08/82	37.0	-	09218
	27/09/82	34.0	-	09625
	02/10/82	35.0	-	09752
Arctic Grayling	29/09/82	33.0	-	09683
	02/10/82	37.0	-	09754
	20/19/83	42.0	-	01476
Humpback Whitefish	26/07/82	30.0	8	09091
	27/07/82	37.0	-	09098
	27/09/82	39.0	-	09632
	29/09/82	40.0	-	09703
	29/09/82	44.0	-	09708

Incidental Species

Spaghetti tags were also applied to other species captured in the fishwheels. Tags were applied to 3 burbot (Lota lota), 5 humpback whitefish (Coregonus clupeaformis), 3 arctic grayling (Thymallus arcticus), 3 least cisco (Coregonus sardinella), 1 longnose sucker (Catostomus catostomus) and 7 inconnu (Stenodus leucichthys). Two of the humpback whitefish were recaptured downriver in the Alaskan subsistence fishery. One of these fish, tagged on July 26, 1982, was recaputred in a gillnet located near Eagle, Alaska on August 12, 1982. The other humpback whitefish, tagged on September 29, 1982, was recaptured on June 17, 1983 at Eightmile Slough on the Porcupine River. The inconnu tagged August 8, 1983 was recaptured near Eagle, Alaska on October 2, 1983.

Appendix 3 Chinook aerial surveys of Canadian spawning areas conducted by A.D.F & G. (information supplied by L. Barton, A.D.F.& G.).

Date	Survey rating	Drainage	Salmon Counts^{a}			
			1983	1982	1981	1980
		TESLIN RIVER DRAINAGE				
		Nisutlin River				
08/15/83	fair	*Sidney Creek - Hundred Mile Creek	677(24)	576(2)	1610(16)	925(50)
"	fair	Hundred Mile Creek - Rose River	16	11(1)	26	4
	-	Rose River	-	-	1	-
"	fair	Rose River - Wolf Creed	45	48	302	134
"	fair	Wolf Creek - McConnell River	74	60	207	188
"	fair-poor	McConnell River - McNeil River	70(2)	42	309	146(2)
"	fair-poor	*McNeil River - Nisutlin Lake	105(2)	97	168	398(2)
	-	McNeil River	-	6	-	-
			987(28)	840(3)	2623(16)	1795(54)
		Wolf River				
08/15/83	fair-poor	*Wolf Lake - Red River	94(1)	104	395	230
"	fair	Red River - Fish Lake outlet	152(5)	121	107	248(4)
			246(6)	225(0)	502(0)	478(4)
08/16/83	poor	Morley River	89(1)	174(2)	326(3)	265^{b}
"	fair	Swift River	172(1)	31	302	420^{b}
	-	Smart River	-	0	21	52$_{b}$
"	fair	Jennings River	37	40	211	-
	-	Gladys River	-	25	51	-
"	poor	Upper Teslin River	111(14)	-	-	-
			409(16)	270(2)	911(3)	737^{b}
		YUKON RIVER TRIBUTARIES				
		Big Salmon River				
08/14/83	fair	*Big Salmon Lake - Scurvey Creek	189c	174	930	469(11)
"	poor-fair	*Scurvy Creek - Moose Creek	164(4)	161	402	260(28)
"	fair-	*Moose Creek - Bat Creek	155(2)	312(2)	835	537(22)
"	poor-fair	Bat Creek - Souch Creek	22(4)	108	120	87(32)
	-	Souch Creek - downstream 5 miles	-	-	124	123(9)
	-	North Big Salmon - South Big Salmon	-	322	156	-
	-	North Big Salmon	-	69	-	-
"	poor	Northern Lake outlet	28(2)	19	-	-
			558(12)	1165(2)	2567(0)	1476(92)
		Little Salmon River				
08/14/83	poor	*Little Salmon River - Yukon River	101	305(0)	670(0)	276(10)
		KLUANE RIVER DRAINAGE				
08/17/83 ,	fair	Tincup Creek	54	-	-	-

* Denotes index areas.

a Counts given are for live kings, followed by carcass counts in parentheses

b ECFS estimates.

c This index area was surveyed 3 times. Counts were 169,169, and 189.

Appendix 4

Estimated total chinook catch in thousands in Japanese, Western Alaska, and foreign trawl fisheries

YEAR	JAPANESE Japanese Mothership Catch	Estimated Number of Western Alaska Origin	Percentage Western Alaska Origin	Japanese Land Based Drift Gillnet Catch	WESTERN ALASKA Commercial	Subsistence	Foreign Trawl Catch	Total Estimated Catch of Western Alaska Chinook
1956	137	55.4	40.4	18	132.7	-		
57	31	15.2	49.0	33	158.4			
58	46	5.4	11.7	45	181.9	-		
59	68	27.8	40.8	42	195.1	-		
1960	180	135.0	75.0	113	195.7	-		
61	31	13.9	44.8	79	243.1	-		
62	122	29.7	22.3	124	213.1	-		
63	87	40.8	46.9	102	208.1	66.2		315.1
64	410	252.9	61.7	195	260.0	50.5		563.4
65	185	105.5	57.0	93	263.0	52.9		421.3
66	208	111.5	53.6	112	207.5	69.5		388.5
67	128	69.8	54.5	110	284.0	81.9		435.7
68	362	226.3	62.5	88	259.0	54.2		539.5
69	554	435.2	78.5	83	287.6	65.2		788.1
1970	437	344.8	78.9	101	290.8	95.1		730.8
71	206	143.6	69.7	134	283.2	73.8		500.7
72	261	169.5	64.9	103	224.1	66.7		460.3
73	119	47.0	39.5	162	177.4	69.7		294.1
74	361	286.8	79.4	186	180.2	57.3		524.4
75	162	109.2	67.4	135	126.2	77.2		312.5
76	283	167.7	59.2	201	241.5	84.0		493.3
77	93	64.5	69.3	146	296.1	84.1	43.5	488.2
78	105	31.3	29.8	210	380.0	74.6	39.1	525.0
79	126	65.0	51.6	161	412.0	99.3	100.4	676.7
80	704	388.0	55.1	160	312.0	113.3	111.6	922.9
81	88	26.0	30.0	190	509.0	130.0	44.0	709.0
82	107	42.7	40.0	165	490.6	111.2	21.4	665.9

NOTE:
1. Data is from 1981 A.D.F.& G. Annual Management Report - Yukon Area
2. Japanese mothership and landbased drift gillnet catches do not take into account dropout rates.
3. The foreign trawl catch is assumed to be 100% western Alaska and Canadian origin
4. Western Alaska catches include Canadian catches
5. 1982 figures are preliminary estimates

Appendix 5 Chinook Ground Surveys 1982 and 1983

Date	Drainage	1982 Observations		Date	1983 Observations	
		Live	Dead		Live	Dead
19/08-20/08	Little Salmon	350	-	26/08	[a] 31	28
21/08	Blind Creek	6	-		N.S.	
22/08	Michie Creek	148	2		**	
24/08-28/08	Ross River	56	8		N.S.	
27/08	Tatchun Creek	68	5	25/08	[b]234	30
26/08-27/08	Wolf River	37	53		**	
28/08-29/08	Morley River	3	2			11*
01/09	Takhini River	15	14	01/09	[a] 45	60
30/08	Swift River	- None observed-			N.S.	
02/09-08/09	Teslin River	40	11		**	
03/09-04/09	Big Salmon	- *None observed-		18/08-26/08	540	100

N.S. Not surveyed

a - limited survey of selected areas

b - two spaghetti tags were observed, one recovered (tag 16983)

* late survey

** aerial survey

Appendix 6

Chinook aerial surveys conducted in 1982 and 1983.

DATE	SUB-BASIN	DRAINAGE	SURVEY CONDITION	LIVE	DEAD
		1982 Aerial Survey			
Aug. 09	Mainstem Yukon	Klondike R.	Fair	26	14
Aug. 09	Stewart	McQuesten	Fair	34	4
		1983 Aerial Survey			
Aug. 06	(S)	McQuesten	Fair-Good	7	1
Aug. 14	(MY)	B. Salmon Lk. - Moose Ck.	Fair-Good	280	8
Aug. 18	(MY)	L. Salmon Lk. - Bearfeed Ck. Bearfeed Ck. - (mouth)	Fair	0	0
Aug. 20	Pelly	Lapie	Good	0	0
	(P)	Big Campbell Ck.	Good	0	0
	(P)	Pelly R. just below Pelly Lks	Fair	3	2 (40+ Redds)
	(P)	Ross R. below Lewis Lk. (Sheldon Lakes)	Poor-Fair	10	2 (50+ Redds)
	(P)	Riddell R. just below Dragon Lk.	Fair-Good	2	1
	(P)	Russell Ck.	Good	0	0
Aug. 21	(P)	Earn River	Fair	18	5 (50+Redds)
	(S)	Beaver River	Fair	0	0
	(S)	Lansing	Fair-Good	0	0
	(S)	Pleasant Ck.	Fair-Good	0	0
	(P)	Moose River	Fair-Good	0	0
	(P)	Kalzas R. below Big Kalzas Lk.	Fair-Good	0	0
Aug. 22	White	Tin Cup River	Good	26	0 (20+Redds)
Aug. 24	Up.Yukon	Michie Ck.	Good	33	1 (20+Redds
	Teslin	Nisultin mouth to 30 mile	Good	0	0
		30 mile-Sidney Ck.	Good	0	0

Appendix 6 con't

DATE	SUB-BASIN	DRAINAGE	SURVEY CONDITION	LIVE	DEAD
	- ——	Sidney Ck- Rose Ck.	Good	6	8
		Rose R.-Nisutlin Lk.	Good	11	3(50+Redds)
	(T)				
	(T)	McNeil River	Good	0	2
		Wolf River	Good		
		Wolf Lk.-Red River	Good	17	3(40+Redds)
		Red R. -Fish Lk	Good	6	14
		Fish Lk-Nisutlin	Good	10	15
Aug. 26		[2] Teslin R. Lake- 100 Mile Ck.	Poor	5	7(50+Redds)
		100 Mile-Swift R.		0	1
	(T)	Swift River- Boswell Ck.		5	6(20 Redds)
		Swift R. Rusry Lk.- Teslin R.		0	1
Aug. 27	(T)	Morley R.to Morley Lk.	Poor-Fair	9	12(100 Redds)
	(T)	Morley Lk.- Slim Lk.	Poor-Fair	0	0
		Slim Lk.- Morris Lk.	Poor-Fair	0	0
	(T)	Smart River	Poor-Fair	0	0
	(T)	Swift River (Mouth-Swift Lk)	Poor	1	3
		Swift Lk-Smart R	Poor	0	1
		Smart R.-Swan Lk	Poor	18	20
		Swan Lk-McNaughten	Poor	0	0
		McNaughten Ck	Poor	0	0
		Gladys River	Fair	2	0
Aug. 28	(Up. Y)	Nordenskiold	Poor	0	0
	(P)	Little Kalzas	Poor	0	0 (5 Redds)
	(P)	South MacMillan	Poor	0	0
	(S)	Nidderly River	Poor	0	0
	(S)	Hess River	Poor	0	0
Aug. 29	(P)	Husky Dog Ck	Good	0	0
	(P)	Ross R, Lewis Lk - Prevost R	Fair	17	8
		Prevost R-Mouth	Poor	0	6

1 - 100 chinook observed Aug.14 to Aug. 31/83, local inhabitant

2 - Flown with 20-30 km tailwind

Appendix 6 con't

DATE	- ~~SUB~~-BASIN	DRAINAGE	SURVEY CONDITION	LIVE	DEAD
Aug. 30	(W)	Nisling River Lower 50 Km	Poor	2	0(10 Redds)
	(W)	Tincup	Poor-Fair	5	0(50-Redds)
Aug. 31	(T)	Teslin (Tracking Flight)			50+(carcass)
Sept. 1	(T)	Jennings R	Fair-Good	0	1(10 Redds)
	(T)	Lower Teslin		1	0(20-Redds)

Appendix 7

Chinook escapement through the Whitehorse fishway: 1958-1983.

YEAR	FIRST DATE	LAST DATE	TOTAL
1958			224
1959	July 29	September 4	1,054
1960	July 29	September 6	660
1961	August 1	September 6	1,068
1962			1,500 (estimated)
1963	August 6 (count)	August 26	483
1964	August 13 (count)	August 29	587 (537 + 50 estimated)
1965	August 1	August 28	903
1966	July 31	August 29	563
1967	July 25	August 27	533
1968	July 31	September 2	414
1969	July 23	August 26	334
1970	August 2	August 27	625
1971	July 26	September 3	856
1972	August 4	August 28	391
1973	August 2	August 28	224
1974	July 26	August 26	273
1975	August 9	August 30	313
1976	August 10	September 5	121
1977	August 8	August 30	277
1978	July 25	August 30	725
1979			1,184
1980	July 22	September 3	1,383
1981	July 24	August 29	1,555
1982	August 1	September 2	473
1983	July 21	September 1	905

Over a 25 year period the average first day a fish passed through the fishway was July 31, the average when the last fish passed through the fishway was August 31.

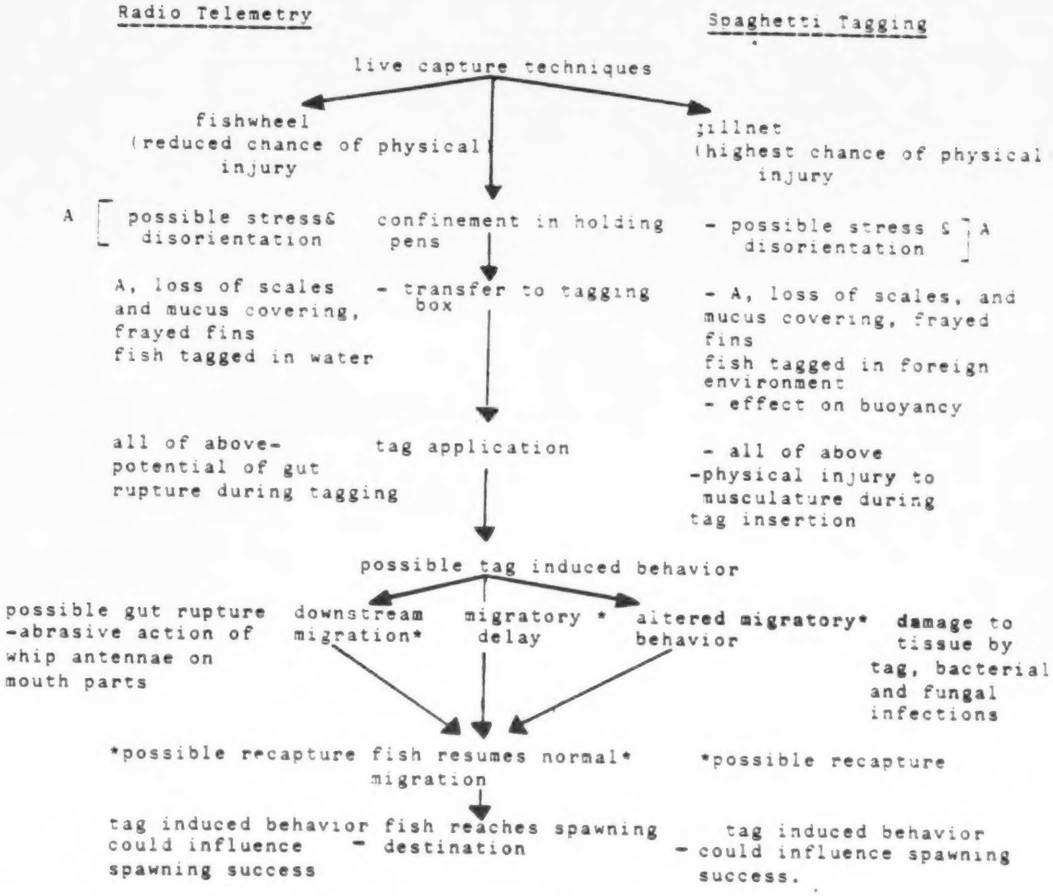
Appendix 8 Schedule of radio-tag application.

DATE	# OF TRANSMITTER APPLIED	LOCATION
July 4	2	Km 4
July 6	5	Km 82
7	3	82
8	2	4
9	5	82
9	3	4
10	3	82
11	2	82
12	5	82
13	1	82
15	3	82
16	4	82
17	5	82
18	5	82
19	4	82
20	5	82
21	5	82
22	5	82
22	5	4
23	3	82
25	7	82
26	5	82
26	2	135
27	5	82
29	3	82
30	3	82
31	1	82
August 1	4	82
2	2	82
2	1	135
3	5	82
4	3	82
6	3	82
7	5	82
8	3	82
9	3	82

Appendix 9 Differences in radio telemetry and spaghetti tagging techniques

Radio Tagging	**Spaghetti Tagging**
Objectives	
- generally directed towards qualitative information	quantitative information
migratory behavior	population estimates
spawning locations	exploitation rates
migration rates	migration rates
Methods	
- internal tag (implant)	external tag
- located near centre of gravity	- loose fitting
- small relative to prey species	- light, does not impede mobility
- tag appl. requires 10 sec.-1 min.	- tag applic. requires 25 sec.-1 min.
- fish tagged while in water	- fish tagged in foreign environment
Results	
- continuous information after after fish is released through aerial or ground tracking.	- no information is generated until fish is recaptured or tag is retrieved from spawning area.
Limitations	
- limitations on signal range due to depth of fish in water, conductivity of water, orientation of receiver etc.	- under field conditions its not possible to directly assess the effect of handling, tagging on the behavior of the fish.
-possible tag regurgitation	- possible tag loss
- possibility that the transmitter may influence behavior.	- possible violations of the conditions in a mark-recapture program.

Appendix 10 Potential behavioral and physiological responses to tagging techniques


Radio Telemetry
Spaghetti Tagging
live capture techniques
fishwheel
(reduced chance of physical injury)
gillnet
(highest chance of physical injury)
A possible stress& disorientation
confinement in holding pens
- possible stress & disorientation A
A, loss of scales and mucus covering, frayed fins
fish tagged in water
- transfer to tagging box
- A, loss of scales, and mucus covering, frayed fins
fish tagged in foreign environment
- effect on buoyancy
all of above- potential of gut rupture during tagging
tag application
- all of above
-physical injury to musculature during tag insertion
possible tag induced behavior
possible gut rupture
-abrasive action of whip antennae on mouth parts
downstream migration*
migratory * delay
altered migratory* behavior
damage to tissue by tag, bacterial and fungal infections
*possible recapture
fish resumes normal* migration
*possible recapture
tag induced behavior could influence spawning success
- fish reaches spawning destination -
tag induced behavior could influence spawning success.

Appendix 11 Chinook spawning areas in association with lake outlets.

Habitat Utilization Code

LO - Lake Outlet
rr - Rearing
sp - Spawning
OW - Overwintering
L - Localized

LAKE BY SUB-BASIN	LOCATION		AREA (HA)	HABITAT UTILIZATION
	LAT.	LONG.		
Yukon Mainstem and Tributaries				
- Claire L.	61°52'	135°21'	2,040	
- Drury L.	62°19'	134°20'	2,700	- OT sp at LO
- Frenchman L.	62°10'	135°50'	1,438	
- Little Salmon L.	62°11'	134°40'	6,210	- sp at LO, mig. good OW potential (sport & domestic fishery
- Tatchun L.	62°17'	136°08'	666	- OT sp at LO, subsistance & sport fishery throughout Tatchun Crk.
Big Salmon R. Drainage				
- Big Salmon L.	61°18'	133°15'		- sp at LO, poss. rr and OW
- Northern L.	61°44'	133°49'		- OT sp at LO poss rr
- Pleasant L.	61°38'	133°23'		
- Quiet L.	61°05'	133°05'	3,780	- OT sp between Sandly L. and Quiet L. poss rr & OW
Nordenskiold R. Drainage				
- Braeburn L.	61°27'	135°48'	558	- Elliot (59) indicated poss. run of OT
- Hutshi L.	61°08'	136°35'	510	- poss. hist OT sp at LO, poss. rr & OW
- Von Wilczek L.	62°42'	136°42'	320	- poss. rr and OW, OT historically sp at L.O.
Takhini R. Drainage				
- Kusawa L.	60°14'	136°16'	14,270	- OT sp at L.O., poss rr
- Taye L.	60°56'	136°21'	843	- OT near L.O. in July /63 (DFO FILES)
- Thirty Seven Mile L.	60°48'	132°31'	350	

Appendix 11 continued

LAKE BY SUB-BASIN	LOCATION LAT.	LOCATION LONG.	AREA (HA)	HABITAT UTILIZATION
Stewart Sub-Basin				
- Ethel L.	63°22'	136°06'	4,730	
- Fairweather L.	63°14'	132°25'	1,890	
- Francis L.	63°27'	135°40'		
- Janet L.	63°41'	135°29'	1,720	- OT sp at L.O poss. rr & OW, sport fishing
- Keele L.	63°30'	130°28'		
- Mayo L.	63°45'	135°04'		- OT historically sp at L.O., dam on Mayo R.
- McQuesten L.	64°07'	135°19'	1,230	- poss. OT sp at L.O., rr
- Niddery L.	63°18'	131°20'	250	- OT sp at L.O., poss. rr and OW
- Penape L.	63°46'	133°48'		
- Pleasant L.	63°32'	132°58'	210	- OT occasionally sp at L.O., poss. rr & OW
- Reid L.	63°26'	137°13'	430	- poss. OT sp at L.O.
- Swan L.	63°33'	132°49'		- OT reported to sp at L.O.
White Sub-Basin				
- Kluane L.	61°15'	138°45'	40,950	- OT sp at L.O.
- Stevens L.	61°43'	137°31'	709	- OT sp - historically at L.O.
- Tchawsahmon L.	61°59'	140°53'	713	- No apparent access
- Tincup L.	61°45'	139°15'	1,790	- OT sp at L.O.
- Wellsley L.	62°21'	139°49'	7,350	- Access obstructed
Pelly Sub-Basin				
- Big Kalzas L.	63°15'	134°35'	4,220	- OT sp at L.O., poss. rr & OW
- Dragon L.	62°35'	131°30'	730	- OT sp at L.O., poss rr
- Earn L.	62°48'	134°17'	3,553	- OT sp at L.O., poss. rr & OW
- Field L.	62°90'	131°03'		- OT sp at L.O., redds observed at L.O.
- Fuller L.	62°59'	130°12'		
- Glenlyon L.	62°25'	134°08'		- OT sp at L.O.
- Itsi L.	62°50'	130°12'		
- Jackfish L.	62°25'	130°10'		
- John L.	62°49'	130°23'		
- Lapie L.	61°36'	133°04'		- OT reported to sp at L.O.
- Lewis L.	62°35'	131°05'	700	- OT sp at L.O.

Appendix 11 continued

LAKE BY SUB-BASIN	LOCATION LAT.	LOCATION LONG.	AREA (HA)	HABITAT UTILIZATION
Pelly Sub-basin cntd.				
- Little Kalzas L.	62°58'	135°35'	993	- OT poss. sp at L.O.
- Marjorie L.	62°07'	131°57'		
- Mist L.	63°12'	134°21'		
- Moose L.	63°10'	134°08'	1,385	- OT sp at L.O., poss. rr at OW
- Narrow L.	63°29'	135°34'		
- Olgie L.	62°07'	132°26'		- OT sp at L.O., poss. rr & OW
- Orchay L.	62°08'	132°42'		- OT sp at L.O.
- Pelly L's	62°05'	130°17'	1,980	- OT sp at L.O., poss. rr & OW, mig.
- Ragged L.	62°38'	135°25'		
- Sheldon L.	62°42'	131°03'		- OT sp at L.O.
- Willow L.	63°12'	136°45'		
Teslin Sub-basin				
- Cabin L.	59°57'	131°43'		- sp reported below L.O.
- Fish L.	60°37'	133°04'		- sp reported below L.O.
- Gladys L.	59°50'	132°50'		- OT sp at L.O., poss rr
- Little Teslin L.	60°29'	133°24'	200	- No access
- Mary L.	60°40'	133°59'		
- McNeil L.	61°14'	132°12'		- OT observed in lake poss. at L.O., rr potention
- Morley L.	60°00'	132°05'	1.110	- OT sp at L.O.
- Morris L.	61°27'	131°40'		- OT reported at L.O., poss. sp from lake to Slim & Morley L.
- Nisutlin L.	61°06'	132°03'		- OT sp between Nisutlin L. & Mcneil R.
- Sidney L.	60°48'	133°02'		
- Slim L.	61°23'	131°39'		
- Smart L.	59°57'	131°46'	140	- OT sp at L.O., poss rr
- Squanga L.	60°29'	133°38'	1,020	- falls on Squanga Crk. prevent use by salmon
- Summit L.	60°26'	133°39'	160	- OT sp at L.O., poss rr
- Swan L.	59°53'	131°24'	890	- OT sp at L.O., poss rr & OW
- Swift L.	60°52'	133°49'		- OT sp at L.O.
- Strawberry L.	60°07'	132°12'		
- Teslin L.	60°15'	132°57'	38,100	- OT sp below L.O., mig. poss. rr & OW
- Thirty Mile L.	60°48'	132°30'		- OT do not ascend creek as far as L.O.
- Wolf L.	60°39'	131°40'		- OT sp at L.O., poss rr & OW

Appendix 11 continued

LAKE BY SUB-BASIN	LOCATION		AREA (HA)	HABITAT UTILIZATION
	LAT.	LONG.		
Teslin Sub-basin contd				
- Wolverine L.	60° 32'	131° 44'		- OT sp at L.O.
- Unnamed L. (on Fat Crk.)	60° 10'	132° 55'		- OT sp at L.O.
Upper Yukon-Southern Lakes				
- Atlin Lake	60° 10'	133° 50'	60.100	- Elliot (59) reported "not uncommon for sightings in this L. historical refs. of OT in lake
- Bennett L.	60° 06'	134° 52'	8,020	- Historically confirmed sightings of OT poss sp. at L.O.
- Coal L.	60° 30'	135° 10'		- OT historically at L.O. and in Wolf Crk
- L. Laberge	60° 10'	135° 05'	21.390	- OT sp at L.O.
- Marsh L.	60° 25'	134° 18'	9,450	- Historical and possibly current at L.O. poss. rr high productivity
- McClintock L.	60° 55'	134° 30'	180	- OT sp at L.O. poss rr
- Michie L.	60° 41'	134° 10'	388	- OT documented. poss rr & sp at L.O.
- Nares L.	60° 10'	134° 39'	530	- poss. utilized by OT historically